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This paper sheds new light on the agricultural side of the Italian regional divide from an economic geography perspective, following a Von Thünen approach. The central hypothesis is that the development of the non-agricultural economy in Northern cities drove the location of agricultural output and inputs during the interwar years. A new database on Italian agriculture around 1930 fully confirms the key role of access to domestic markets in shaping agricultural activity. Thus, the causes of the falling behind of Southern agriculture are uncovered: it is not very surprising that an agricultural divergence joined an already ongoing industrial divergence during a period in which international markets collapsed.

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1. Introduction. Two old charges and a new puzzle: the North-South agricultural divergence of the first half of the XXth century.

Historiography on pre-war Italian agriculture has undergone a considerable change since the early nineties. The role played by agriculture in Italian economic history before WWII used to face two important charges, that today have been to a large extent removed.

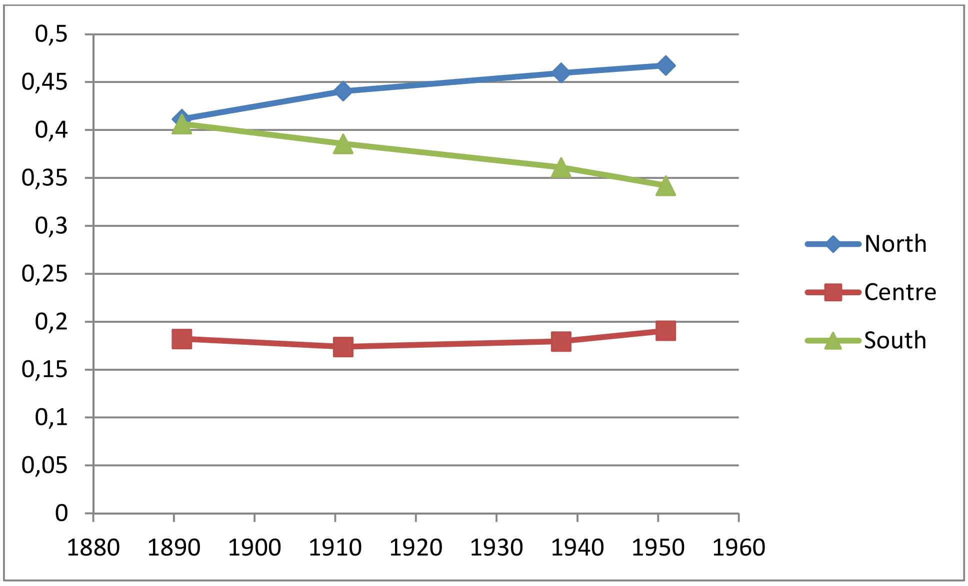
The first charge is related to the national long run evolution of the agricultural output and its causes (Cohen and Federico, 2001 and Federico, 2003). The performance of the agricultural sector before WWI is now considered much more positive than before, following the new estimates of Italian agricultural output between 1860 and 1910 by Federico (2003). The new estimate corrected the traditional one, the so-called ISTAT-Fuà series (Vitali, 1975), based on flawed official statistics that severely underestimated output in the 1870s and 1880s. Aggregate growth seems to have been more sustained than what was traditionally thought. National TFP seems to have grown at a rate comparable to the European average in the pre-war years (Federico, 2009). So one of the traditional charges moved against Italian traditional agriculture has been seriously dismantled: agriculture is not anymore seen as a backward sector unable to implement any kind of technological change, and, as such, responsible for a great deal of Italy's late industrialization (Sereni, 1947). Interwar agricultural output is still to be revised, but it will hardly change the whole story since its poor performance seems to match well with the European experience during these years; moreover, the original series for this period is based on allegedly more reliable sources than the pre-WWI one.

The second charge faced by Italian agriculture was to have played an important role in the emergence and persistence of the enduring North-South regional divide (Zamagni, 1993). Southern Italian agriculture was traditionally considered very poor, but this conventional wisdom was based on anecdotal evidence (Federico, 2007). Low productivity was explained by different combinations of natural constraints and inefficient institutions, but it played a prominent role in explaining the poverty of Southern Italy already when the public debate on the so-called "Southern Question" opened up in the late nineteenth century (Daniele and Malanima, 2011, Felice, 2011). The alleged poor performance of Southern agriculture kept low the level of income per capita, constrained local demand for non-agricultural products and avoided the release of labour force to other sectors, thus being a major force in the area's falling behind. Federico's (2003) estimates of regional value added for four benchmark years (1891, 1911, 1938 and 1951) have challenged this conventional wisdom. While output per hectare has always been higher in the North (as pointed out by Felice, 2007), agricultural value added per worker appears now to have been higher in the South than in the North at the turn of century. Estimates of the North-South agricultural gap at the time of Unity (1861) would be desirable, but it is unlikely that we are going to have them in the very short run, since reliable data for those years are too scarce. Brunetti et al. (2011) have recently published an estimate of regional GDP per capita in 1871, in the context of long run estimates of regional GDP per capita by and large based on Felice (2011), who in turn relies on Federico (2003) for the agricultural sector. Their GDP estimate for 1871, based on Felice (2009), is only partially consistent with Federico (2003) for the agricultural sector (due to his treatment of animal products). However, the interpretation of the post-Unitary history is unlikely to change with respect to what we already know on 1891 agriculture: either the South was below the North in 1861, implying faster growth for the South between 1861 and 1891, or the former was (even more) above the latter, implying that Southern success was constant during the whole period, though with a diminishing advantage.

In any case, Southern agricultural history before the end of the century was a relative success. This fact has lead to a rather radical reinterpretation of Italian economic history during the period, as pointed out in Daniele and Malanima (2011), Felice (2011) and Brunetti et al. (2011). Thanks to the relatively good performance of agriculture, the income gap between Northern and Southern regions was relatively contained in 1891. Agricultural productivity was higher in the South, but an ongoing process of industrialization in the North implied that a small gap in income existed already at the end of the century, with value added per worker in the South 6% below the national average and a GDP per capita 12% below the national average in 1891 (Felice, 2011). Thus, the gap was noticeable but not enormous. Backward extrapolation exercises point out to a gap between Southern income per capita and the national average at the time of Unity substantially similar, with an order of magnitude of between 0% and 10% in 1861 (Daniele and Malanima, 2011) or close to 10% in 1871 (Brunetti, et al., 2011). So today scholars tend to consider the emergence of the North-South income gap much more an issue of the first half of the twentieth century than of the late or mid nineteenth century, with a special emphasis on the interwar years, when the gap boomed reaching the historical maximum of a Southern GDP per capita 40% lower than the national average in 1951. Agriculture is not seen anymore as a villain in the whole story (at least not so a relevant one), as it seems clear that it was mainly the South's failure to industrialize what caused its falling behind. As agricultural labour productivity was higher in the South than in the North at the beginning of the industrialization process, the industrial failure of Southern regions itself could not have been caused by an initially lower agricultural productivity. Thus, the former "pessimist" conventional wisdom about Italian agriculture has been eroded, and to a large extent substituted, by the widespread emergence of "optimistic" interpretations (Cohen and Federico, 2001).

Still, agriculture seems to have been an important actor in the whole process. Indeed, the new picture makes agriculture playing an unexpected role in the divergence story, a role even more puzzling than the traditional one. Indeed, while Northern regions industrialized, during the first half of the twentieth century Southern regions not only failed to do so but lost their initial relative advantage in the agricultural sector. This late and unexplained agricultural falling behind joined the industrial divergence and caused the extreme regional polarization in income per capita between Northern and Southern regions, a polarization that the country, after a limited post-war convergence lead by massive state intervention, has not recovered from ever since. Two features characterise the Southern agricultural falling behind. First, output increasingly concentrated in the North. The share of Southern regions[2] in the national gross sealable production systematically fell between 1891 and 1951, while Northern regions' share systematically grew (see figure 1).

Graph 1: Southern Italy Agriculture's Falling Behind (I) - Declining Share of National Output

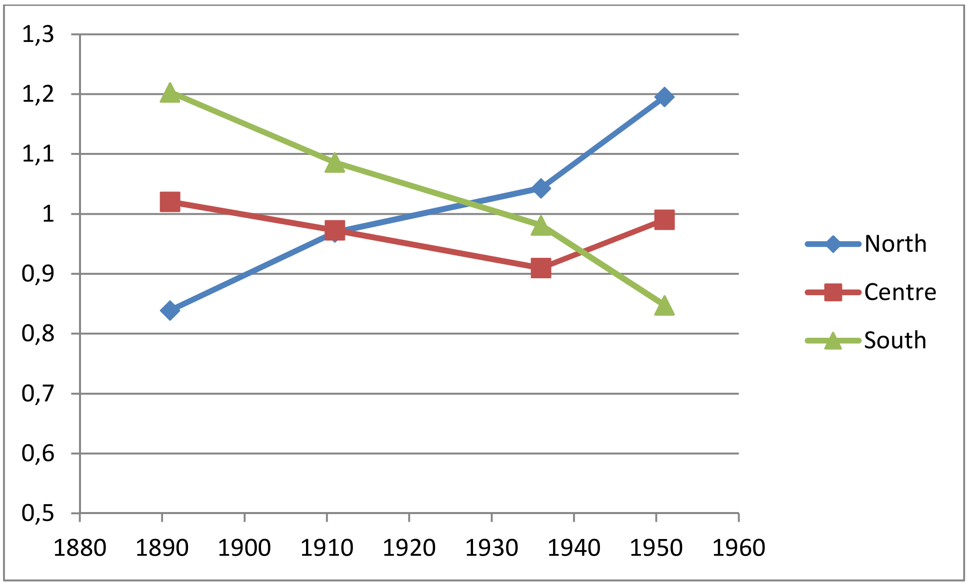


Source: Own elaboration based on Federico (2003). In order to assure intertemporal comparability, National output is computed excluding in 1938 and 1951 the Northern acquisitions after WWI, i.e., the regions of Venezia Tridentina/Trentino-Alto Adige and Venezia Giulia/Friuli-Venezia Giulia in 1938 and 1951 (the latter partially lost after WWII). The province of Udine, accounting for something as 1.5% of national output in 1936-1938, was transferred from Venetia to FVG after WWII, and hence the share of Northern regions in National output in 1951 is actually slightly underestimated.

[2] Throughout this chapter I will refer to "North" as the sum of Piedmont, Liguria, Lombardy, Venetia and Emilia, to "Centre" as Tuscany, Umbria, Marches and Latium, and to "South" as Abruzzi, Campania, Apulia, Basilicata, Calabria, Sicily and Sardinia.

Second, labour productivity grew systematically faster in the North than in the South. Between 1891 and 1951, the relative superiority of Southern regions in terms of per worker productivity not only was eroded but, eventually, even reverted (see figure 2). Regions of Central Italy fit somewhere in the middle of the Northern and Southern absolute and relative performances: the Centre managed to keep rather constant throughout the whole period both its share in national output and its relative labour productivity, even if the latter was reverted to its initial level (around the national average) only after decades of slow decline. As a consequence, the falling behind of the South was absolute, as output grew at lower rates, and relative, as it was driven by lower rates of labour productivity growth.

Graph 2: Southern Italy Agriculture's Falling Behind (II) - Declining Relative Labour Productivity (Italy=1)



Source: Own elaboration based on Federico (2003) for output (GSP) and Vitali (1968) for labour force. National and Northern Labour Productivity are computed excluding in 1938 and 1951 the Northern acquisitions after WWI.

Thus, why this agricultural falling behind did happen is now the real big question of Italian post-unitary agrarian history. The proximate causes necessarily are to be found in some mix of factor accumulation and technological divergence, i.e. differentials in TFP growth. But, whatever the relative importance of factor accumulation and technical change in explaining the Southern agricultural divergence, it is worth bearing in mind that these were just proximate causes. The ultimate causes are even more mysterious, although they are the really important ones. Why should either factor accumulation or technical progress diverge so systematically for so a long period across the main sections of the country? In principle, one may be tempted with bringing in from the cold some of the traditional “pessimist” claims, such as Southern peasants’ or (more importantly) landowners’ unwillingness to invest or to be actively involved in the management of their estates, institutional inefficiencies related to outdated contracts, and so on. But it would be hard to explain why these factors started to have a negative impact on Southern performance only at the end of the nineteenth century. Moreover, such claims have been convincingly criticised (see Cohen and Federico, 2001 and Federico, 2003). So it is unlikely that we are going to find in such arguments the ultimate causes of Southern agriculture’s falling behind.

The more recent trends in Italian economic history tend to focus on the role of “intangible” determinants of North-South regional balances, as human and social capital (Felice, 2010). There are not studies on the effects of these factors on the evolution of a particular sector, but the available quantitative evidence points out that their role as determinants of aggregated growth changed in different stages of development, with human capital being a significant determinant during the interwar years (Felice, 2012). While these factors may have in some way contributed to the agricultural divide, they seem to be more associated with the second industrial revolution. Hence, looking for a complementary approach seems desirable in order to explain the agricultural divergence. In the next section I explore a simple mechanism for the falling behind of Southern agriculture. As an ultimate cause I focus on access to domestic markets during a period of distress in international trade. Despite it is not necessary to think that the process was driven by a single cause, access to markets is a good candidate to have been a main actor. It directly links the two sides of the Italian regional divide, the rise of industry in the North and the agricultural divergence, in a single story. As such, its explicative power is especially attractive. Since we can rely on well-established economic theories about the relationship between access to markets and the spatial patterns of agricultural activity, a formal model can be used to derive testable predictions. It is not possible to test a dynamic version of the model at the present stage of the research, but we can test several different predictions derived from the model in its static version in order to verify whether it is an adequate description of the Italian agriculture at the midpoint of the divergence. In the next section I describe the model, the main predictions and their relationship with the available data. Later, I provide formal statistical tests of the main testable hypotheses and, after including some robustness checks, I discuss them. Finally, I conclude.

2. Analytical Framework: Access to Markets and Spatial Patterns of Agricultural Activity.

Economic geography models are usually used to explain the uneven spatial distribution of industrial activity. These kind of models rely mainly on the seminal framework laid on by Krugman (1991) and further refinements of it (Puga, 1999), i.e. on the so-called New Economic Geography. The use of these economic geography models in addressing historical questions is relatively recent. Nonetheless, the increasing interest of economic historians in economic geography has been mainly focused on the manufacturing sector (Kim, 1995, Wolf, 2007, Martínez-Galarraga, 2012, Klein and Crafts, 2012). Agriculture is occasionally involved in the analysis, but it merely does so as an exogenous determinant of income, with industry generally still being the main subject of interest (Rosés et al., 2010, Combes et al., 2011). The Italian case, maybe the paradigm of spatial polarization of economic activity in Europe, constitutes a somewhat surprising absence in this brand of literature. The first attempt to explicitly adopt a NEG framework in order to explain the long-run performance of Italian regions is A'Hearn and Venables (2011), produced in the context of a research project promoted by the Bank of Italy in order to celebrate the 150th anniversary of the unification of (the main part of) the country. This very explorative paper states that access to markets was a key determinant of the growth pattern of Italian regions. According to its framework, the North was better suited than the South for taking advantage of the specific conditions of every successive period since unity. If natural advantage was the main determinant of economic activity from 1861 to 1890, in 1890-1950 the key was access to domestic markets and after 1950 it was access to international markets. It is to be expected that more research along the lines depicted by A'Hearn and Venables (2011) will come, especially since the main contribution of the paper is to set the main framework and a general interpretation, without much quantitative evidence or a systematic statistical analysis. Nonetheless, their main focus is, again, on industry, and the importance of industry in explaining the North-South divergence. This leaves the increasing concentration of agricultural output in Northern regions unexplained, as does with the productivity divergence.

This lack of interest of economic geography models in the agricultural sector seems a little bit paradoxical when we take into account that the first model of spatial distribution of economic activity precisely focused on agriculture: the Von Thünen model (Von Thünen, 1826) aimed at explaining the patterns of land use around a central city. Writing in the first half of the nineteenth century, the work of Von Thünen was very advanced for his time, and to a large extent predated marginal analysis much before the emergence of neoclassical economics. Consequently, it was rather neglected for decades, at least outside the specific field of urban economics (Krugman, 1991). In the second half of the twentieth century the Von Thünen model has been refined with mathematically rigorous formulation within the neoclassical framework (Beckman, 1972, Samuelson, 1983), but its empirical applications have still been scarce. Particularly, the model has not found much application in historical economics. The recent contribution of Kopsidis and Wolf (2012) for the first time makes use of a Thünen-inspired framework in a historical economic analysis. In their path-breaking paper access to urban markets is found to have been a key determinant of agricultural patterns across nineteenth century Prussia, explaining the East-West gradient in Prussian land productivity.

In this paper I will address the question of the interwar agricultural divergence of Italian regions strongly relying on Kopsidis and Wolf (2012), in turn partly inspired by Beckmann (1972). I will simplify their framework in some points while expanding it in others, in order to better adapt it to the problem at hand. The main components of the model are as follows.

First, a central market city with given population *N* is exogenously located in a featureless plain. In stake of simplicity agricultural production is represented by a single commodity, Q, with unitary price at the central market *p*.

In any location situated at distance *d* from the central market, agricultural output is produced with a Cobb-Douglas production function:

(1) $Q = AK^{\alpha}L^{\beta}T^{\gamma}, \quad (\alpha + \beta + \gamma = 1)$

Agricultural production uses capital, *K*, labour, *L,* and land, *T*. *A* is a scalar capturing exogenous differences in efficiency and in environment; one might think of it as a composite variable capturing the effects on productive factors of human-origin technology as well as of physical and environmental conditions. Since any unit (say, hectares) of land represents a location and is fixed, it will be useful to represent the production function in per hectare terms by dividing both sides of (1) by *T*:

(2) $q = Ak^{\alpha}l^{\beta}$

The price of agricultural output at the central market is an increasing function of the city's population:

(3) $p = f(N), \qquad f' > 0$

At every location situated at distance *d* from the central market, farm gates p_d must discount transport costs. Transport costs are assumed to be of a general form, with an ad valorem (t_1) component and a per unit (t_2) component:

(4) $p = p_d(1 + t_1 d) + t_2 d$ or $p_d = \frac{p - t_2 d}{(1 + t_1 d)} = \frac{f(N) - t_2 d}{(1 + t_1 d)}$

Farm gate prices at every location are increasing in the population and decreasing in distance from the central market city.

At every location, rent per hectare is defined as:

(5) $R_d = p_d q - rk - wl = y - rk - wl$

that is, output valued at farm gate prices (y) minus production costs.

Landowners' maximization of R_d yields landowners factor demands which, given factors prices, denotes the equilibrium factor intensity:

(6) $l_d{}^* = \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{\gamma}} \left(\frac{\beta}{w}\right)^{\frac{1-\alpha}{\gamma}} A^{\frac{1}{\gamma}} p_d{}^{\frac{1}{\gamma}}$

(7) $k_d{}^* = \left(\frac{\alpha}{r}\right)^{\frac{1-\beta}{\gamma}} \left(\frac{\beta}{w}\right)^{\frac{\beta}{\gamma}} A^{\frac{1}{\gamma}} p_d{}^{\frac{1}{\gamma}}$

where the subscript d emphasizes that factor intensity at every location d is a function of its distance from the market city. Similarly, physical output per hectare at every location is:

(8) $q_d{}^* = Ak^{*\alpha} l^{*\beta} = \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{\gamma}} \left(\frac{\beta}{w}\right)^{\frac{\beta}{\gamma}} A^{\frac{1}{\gamma}} p_d{}^{\frac{1-\gamma}{\gamma}}$

And the value of output per hectare is:

(9) $y_d{}^* = p_d q_d{}^* = \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{\gamma}} \left(\frac{\beta}{w}\right)^{\frac{\beta}{\gamma}} A^{\frac{1}{\gamma}} p_d{}^{\frac{1}{\gamma}}$

It follows that equilibrium rent per hectare is:

(10) $R_d{}^* = y_d{}^* - rk_d{}^* - wl_d{}^* = \gamma \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{\gamma}} \left(\frac{\beta}{w}\right)^{\frac{\beta}{\gamma}} A^{\frac{1}{\gamma}} p_d{}^{\frac{1}{\gamma}}$

Given this framework, it is easy to see that four key variables of the model, that is labour per hectare, capital per hectare, the value of output per hectare and rents per hectare, are all in equilibrium increasing functions of the central city size. At the same time, they are all decreasing functions of distance to the city. This means that agricultural activity will be spatially distributed following a gradient of decreasing intensity around the central city. Rents, mobile inputs and output per hectare will all follow such a pattern. Moreover, physical output per hectare will be higher the closer we get to the city. The last fact is important from an empirical point of view: even if output is valued imperfectly due to unavailability of farm-gate prices, it may follow an intensity gradient around the city.

Equations (6), (7), (9) and (10) provide a straightforward strategy to test the Von Thünen hypothesis. If access to markets was driving agricultural production, we must find all the four aforementioned variables to be increasing in market city size and decreasing in distance to it. In the real world there is more than one city. A customary way to capture the plurality of demand foci is to build up a measure of access to markets for a given location as a weighted average, where the weights are given by the respective distances to all other locations.

Data required for estimating the model, as well as the sources used, are described in the Appendix.

4. Analysis. Testing a Von Thünen model for Italian Interwar agriculture.

The specification to test whether output followed the pattern depicted by equation (9) takes the form:

(12) $\ln y = a + b \ln AM_n + x'\delta$

The dependent variable in (12) is the logarithm of agricultural output per hectare, ln AM_n the logarithm of the n-th definition of Access to Markets and x' a vector of control variables. With the data presented in the Appendix we are equipped to test the main hypothesis derived from the analytical framework. First we should define a measure of access to markets for a given location. The usual form of such measures takes the form of a weighted sum of the form:

(11) $AM_i = \sum_{j \neq i} \frac{Population_j}{Distance_j} + 2 \frac{Population_i}{\sqrt{\frac{Area_i}{\pi}}}$

where the subscript *i* denotes the i-th agrarian zone, whose access to markets is to be measured. The variable distance measures the distance between the gravity centre of any pair of agrarian zones. The gravity centre is defined as the weighted sum of coordinates (latitude and longitude) of all the municipalities included in the agrarian zone, with population in 1931 being the weights. Data on latitude and longitude for every Italian municipality at 1931 boundaries were provided by the Italian Army's Geographical Institute and published in the 95 volumes of the 1929 Agrarian Cadastre. In order to take into account the curvature of the Earth and the fact that the length in kilometres of one degree of longitude varies with latitude, coordinates are projected on a plain surface and degrees are converted in kilometres (measured from Rome's parallel and from the Equator). Coordinates' adjustment is described in the Appendix. Access to markets is defined as the sum of two components. The first component measures access to markets other than the considered location itself. The second component measures the access of a location to its own market. It is assumed that every location's own population is located halfway between the centre of the location's centre of gravity and its imaginary external boundary (defined as a circle centred around the centre of gravity with the same area of the actual area of the given location). The way population is weighted (Inverse Distance Weighting) implies that economic distances are proportional to air distances. This is obviously an oversimplification, but I claim that this procedure is reasonable in the present context and, with all its shortcomings, it does not qualitatively qualify the results. First, land distances may be reshaped by differential access to transportation means as roads and railways. Since transportation infrastructure was particularly dense in the Northern part of the country (particularly between Milan and Turin), obviating it actually results in an underestimation of access to markets in North-Western Italy, which would be increased by a proper measurement of terrestrial distances. Second, in a country like Italy, with so many coastal areas, geodesic distance may not measure well the economic distance if differences in transport costs between the relevant alternatives are significant, that is if railway (which is assumed to be the cheapest transport mean by land) and shipping have unitary costs of different orders of magnitude. Comparing transport costs for the five years before march 1930, when the main production decisions affecting agricultural output in 1929-1930 are likely to have been taken, reveals that the cost of transport by railway and by ship was of the same order of magnitude, and indeed seems to have been slightly higher by ship until January 1930 (see the Appendix). So, if anything, access to markets of, say, Palermo is somewhat overestimated in comparison with that of, say, Milan.

What exactly is to be considered as representing the "central urban market" of the model, i.e. the sources of demand for agricultural output, is not unambiguous. Firstly, what "urban" means is controversial. Secondly, demand for agricultural products could come from proper cities as well as from a large set of legally small municipalities with high population density and high levels of industrialization (a definition matching the features of some industrial districts in Northern Italy). An easy way to overcome these definition problems is to test the same specification with several different definitions of access to markets, involving different categories of potential demand. Results are shown in Table 1. In column 1 Access to Markets is measured by the broadest definition of market, i.e. total population according to the 1931 Population Census. As expected, the coefficient is positive and statistically significant. Being in the very nature of an elasticity, the coefficient points out to a 1.32% increase in output per hectare as a consequence of a 1% increase in access to markets. In column 2 only population living agglomerated (i.e., excluding isolated houses), as reported in the Census, is considered as a source of demand. Column 3 reports the results obtained by considering as a source of demand only agglomerated population living in centres with more than 10,000 inhabitants. Results are similar in every case. However, a further caveat may be raised against all these access to markets measures: population engaged in agriculture is included therein, and thus suppliers and demanders are counted altogether. This may bias the estimates. To avoid this problem, equation (12) is tested considering two measures of non-agricultural population, which surely represents exclusively the demand side of markets for agricultural products: the first one considering access to families whose family-head was not employed in agriculture and another one considering access to the number of members of such families. Scholars (Vitali, 1968) have argued that some Italian Census, including the 1931 one, underestimated the number of women employed in agriculture. By considering both the number of families (which essentially reflected male employment in agriculture) and their members the analysis covers both the upper and the lower bounds of actual employment in agriculture. Columns 4 and 5 report the respective results. The coefficients are slightly reduced with respect to the previous three cases, probably reflecting the deletion of an undesired effect of relevant agricultural labour input in big municipalities on agricultural output. But even the effect of these more restrictive definitions of access to markets remains high and of a comparable order of magnitude, with an elasticity slightly above unity. Moreover, in all cases access to markets seems to be a main driver of agricultural output: according to the R-squared statistic, this variable alone explains between 31% and 54% of the variation of output per hectare throughout Italy. This is a remarkable result given that it is obtained without ever considering any other physical, economic or social element relevant for agricultural production other than access to markets. However, this result may be due to a generic North-South gradient or to regional characteristics correlated to access to markets. In order to test this possibility, column 6 reports the results of a regression with the same definition of access to markets used in column 5 with a set of regional dummies as additional explicative variables. The coefficient of access to markets actually increases by something as 50% and maintains its high statistical significance, suggesting that its effects on output were not merely a fact of inter-regional (or, more simply, North-South) differences but that it actually explains intra-regional variations of output per hectare.

These initial results suggest that a Von Thünen model is worth-exploring as an explicative framework for Italian agriculture. But even so, it is unlikely that agricultural output was exclusively driven by access to markets. Further robustness checks are required before we can conclude that access to markets actually shaped Italian agriculture, since its effects may vanish once we consider the impact of differences in the physical environment or socio-economic variables. The Von Thünen model is built upon the assumption of a featureless plain around a central city, and the geography of Italy is very far from anything like that. Physical characteristics may strongly constrain agricultural potential and may reflect differences in the shifter parameter A of the production function. First, I include as a control the average altitude of each agrarian zone, obtained as an area-weighted average of the altitude of its constituent municipalities (available from 95 provincial volumes of the 1929 Agrarian Cadastre). From the same source I also compute a measure of the slope of the terrain, using information on the absolute maximum and minimum altitude as well as the maximum and minimum altitudes within which the main part of every single municipality laid. Malaria was still an important disease in some areas of the country despite the efforts to eradicate it. Thus, from ISTAT (1938) I construct a variable which measures the share of the agrarian zone's land represented by municipalities where malaria had ever been declared endemic (a feature which may diminish the agricultural potential of a given area). While I have already discussed the reasonability of the use of inverse distance weighting, a control variable of distance to sea is introduced in order to correct any measurement distortions attributable to it. A dummy variable for agrarian zones which were islands is also included. Finally, the rainfall regime is a key determinant of the agricultural possibilities of any area. Data on monthly rainfall and on the number of rainy days for 4,632 climatic stations all around the country is available from a series of publications (*Annali idrologici*) published by several semi-regional authorities working under the Ministry of Public Works (Ministero dei Lavori Pubblici, 1936-1939). From this source I obtained a database, made of over 400,000 data points, which allows to fully reproduce the Italian rainfall regime during the thirties by averaging data on the available four years (1936 to 1939) regarding 14 variables: the average total yearly rainfall and its coefficient of variation, the average seasonal rainfall and their coefficients of variation and the average seasonal rain intensity (measured as the amount of rainfall divided by the number of rainy days). The last available geo-physical variable is latitude, which affects the length of the growing season together with altitude and the rainfall regime (already taken into account).

Along with physical and geographical controls, I include socio-economic controls as well. The first set of such controls regards agrarian institutions, the black beast of traditional Italian historians for so long (see Cohen and Federico, 2001). First, differences in the prevailing agrarian contracts are taken into account by including the share of the labour force employed in agriculture being respectively an owner operator, a rented tenant or a sharecropper. Data are taken from the Population Census of 1936, since the 1931 Population Census did not report employment data at agrarian zone level and the respective shares of every category are not likely to have changed much in five years. Secondly, potential effects of inequality in operational sizes or of inequality in landownership (adjusted by value) are accounted for. The first variable is measured by a Gini index of inequality computed over the farm-size distribution reported by the 1930 Agricultural Census. The second variable is measured by a Gini index computed over the rent-distribution (valued at 1937-1939 prices) of actual ownerships, resulting from the merging of all plots and farms belonging to the same owner within an agrarian zone, as reported in a massive official inquiry (INEA, 1946-1948) carried on at the end of WWII and reflecting the distribution of the value of land as an asset at the end of the 1930s. From the same source I take the average rent per property (computed as the economic rent, and hence as the actual return to land after deducting all imputable variable and fixed costs, including the cost of the owner's work. The latter is a measure of the average value-adjusted size of the ownerships of a given zone, which may have been relevant if there were economies of scale of any type. Rents, as reported in this source, also allow to test equation (10). Finally, the share of land belonging to collective entities (mainly public or semi-public) is included as a control for any potential difference between private and collective landownership management. The source is always INEA 1946-1948. Another set of socio-economic controls regards human capital accumulation and socio-demographic measures. The only measures of human capital available at agrarian zone level are the literacy rate and the gap in the literacy rate between females and males (measured as the former's rate over the latter's), from the 1931 Population Census. From the same source it is possible to derive the female-male ratio, which may have been a proxy of emigration/immigration intensities, given the characteristics of migrations during this period. The share of population older than 10, reported in the Census as well, is used as a very rough proxy of birth rates, which are not available at agrarian zone level. Another measure of age structure, and the only sector-specific available, is the average size of families whose head was employed in agriculture. Finally, the last socio-economic variable is the share of spread population, i.e. the share of population living in isolated dwellings in the countryside.

Table 2 reports the results of the successive implementation of all controls. Access to markets is defined, following the most restrictive definition, as the same variable used in the regressions reported in columns 5 and 6 of Table 1, namely access to inhabitants depending on economic activities other than agriculture[3]. First, the role of agrarian institutions is assessed. All variables, with the exception of asset-inequality (not significant) and value-adjusted size (positive and significant at 10%), have a negative and statistically significant effect on output per hectare. Despite these first results may be encouraging for traditional historians, the implementation of further controls almost totally vanishes the negative effects of agrarian institutions, with the exception of the share of owner operators and of land belonging to collective entities, whose coefficients shrink

[3] Other estimates using alternative definitions yield basically the same results, and are available upon request.

anyway with respect to the initial estimation. Similarly, no socio-demographic variable is significant at conventional levels after physical variables are taken into account, with the exception of the female-male ratio, with a weak significance at 10%. What the results of Table 2 suggest is that most of the socio-economic features, apparently driving agricultural performance, were ultimately determined by environmental features (with the notable exception of ownership patterns). Indeed, the majority of variables with explicative power are of physical nature: as expected, altitude, malaria potential and distance to the sea had a negative impact on agricultural output, as had latitude. Other variables display more puzzling results, as a positive impact of ruggedness. Possibly this result reflects the fact that, once average altitude is taken into account, some range of variation of altitude within a given agrarian zone allows for positive complementarities. High quality vineyards were often found in hill slopes, rather than in the plains, and this effect can largely account for the sign of the coefficient. Also many rainfall regime variables are statistically significant. But despite the strong explicative power of physical variables, the coefficient of access to markets is hardly changed, even after including more than 30 control variables. Its statistical significance remains high, always at 1%. The elasticity of output with respect to access to markets fluctuates in all specifications around values slightly above unity, in a surprising reduced range (between 1.088 and 1.231). This fact is worth stressing since few "human originated" variables resist the introduction of "nature made" variables into the analysis. Summing up, Table 2 strongly confirms the existence of a Von Thünen pattern in Italian interwar agriculture.

The Von Thünen model described in section 2 not only predicts a gradient of output intensity around foci of demand sources. It also predicts that this will be generated by an input intensity gradient and will result in another gradient in rents per hectare. With the available data, it is possible to test all these hypotheses as well, and hence get stronger evidence of the accuracy of theory as a description of the real world. If four different predictions derived from the same model are found consistent with reality, these findings result in a strong confirmation of the theoretical correctness of the model. Otherwise, results found in Table 2 may be driven by spurious correlation and additional research would be needed. Hence, in Table 3 I report the results of estimating (13), (14), (15) with the available database.

(13) $\ln l = a + b \ln AM_n + x'\delta$

(14) $\ln k = a + b \ln AM_n + x'\delta$

(15) $\ln R = a + b \ln AM_n + x'\delta$

Each variable is first regressed exclusively on access to markets, and then the same full set of control variables used in column 5 of Table 2 is introduced. As said, employment in agriculture at agrarian zone level is not available for 1931, so I use as dependent variables both the (log of the) number of families whose family head was employed in agriculture per hectare, which proxies the lower bound of agricultural employment, and the number of members of such families per hectare, which represents the upper bound. The results, with respect to our variable of interest, are very similar in both cases. Indeed, results are very similar when we consider the impact of access to markets on either labour input per hectare, capital input per hectare or rents per hectare. As predicted by the model, higher access to markets results in higher inputs, labour and capital, per hectare and higher rents. Access to markets alone explains close to one third of the variation of output and capital per hectare, as well as between one quarter and one third of variation in labour per hectare and a fifth of variation of rents in the whole sample. The elasticity is in all cases close to unity, and, noticeably, remains rather unchanged (as well as its statistical significance) even after the inclusion of a large set of controls. The results displayed in Table 3 strongly support the inference already derived from Table 2. The divergence of Italian agricultures in the first half of the twentieth century may very well be explained by the growth of the non-agricultural sector in Northern Italy (and especially in its North-western part), since the whole pattern of the sector suggest that it reacted positively to geographic access to sources of demand in sectors other than agriculture. According to this framework, higher access to markets resulted in higher intensity in the use of productive factors (other than land) per unit of land.

Table 3 has shown that data support this channel. But it is possible to directly explore the mechanisms through which access to markets shaped agricultural activity. It is easy to see that the equilibrium output per hectare at a location d may be expressed as:

(16) $\ln y_d{}^* = \ln A + \alpha \ln k_d{}^* + \beta \ln l_d{}^*$

That is, access to markets shapes output per hectare by shaping factor intensities. We can explicitly estimate 16 in order to check such a mechanism. The results are displayed in Table 4. According to (16), once we regress output per hectare on capital per hectare, there should still be an effect of access to markets, which determines labour per hectare as well. Vice versa, when regressing output on labour, access to markets must have a positive effect as it determined, besides labour inputs, the unaccounted for capital input. Indeed, statistical results confirm this mechanism. When just one input (either capital or labour) is included as a regressor (columns 2 and 3), the coefficient of access to markets shrinks but remains statistically significant. Column 4 shows that after both labour and capital are simultaneously taken into account, access to markets still has a positive and highly significant effect, despite the magnitude of the coefficient being reduced to a mere 25% of its initial value. The latter is an unexpected result, since according to the theory there is no room for access to markets shaping output after factor uses are taken into account. A possible explanation for this result is measurement error: there may have been areas with high access to markets having some items of capital unaccounted for in the present estimate. Another explanation may be related to a higher *A* in areas with high access to markets: closeness to sources of demand may have provided a better access to information, thus allowing specialization in more risky, though more profitable, products (for example). However, it shall be stressed that the residual quantitative effect of access to markets is small if compared with its direct effect via factor intensity. Putting it another way, access to markets strongly determined agricultural production, with elasticity close to unity; 75% of its effects are explained by factor use, and a residual 25% through still unexplained channels.

A further doubt may be raised. Access to markets may determine higher agricultural output, but if agricultural suitability favours the growth of non-agricultural activities, access to markets may be endogenous. In those cases, OLS estimation would be biased. Despite agricultural suitability may determine non-industrial growth in a location but not necessarily in its neighbourhood (which is what is measured by access to markets), the issue deserves a proper research strategy. A fully exogenous variable is required in order to estimate (12) by instrumental variables. I use the access to the HP generated by motors moved by water-power in the 254 main industrial municipalities as reported by the 1911 Industrial Census. This is surely an exogenous variable for two reasons. First, it is related to a previous period, and hence it cannot be determined by the dependent variable. In this sense, it constitutes a proper lag, which is a usual procedure in these contexts. Second, HP generated by water in 1911 in the main industrial municipalities is related mainly to hydroelectric power, whose development was correlated to local conditions for the use of waterfalls as a source of electric power and not to agricultural output; most of these municipalities were in the Alpine belt around Turin and Milan. Results of IV estimation are shown in Table 5. The first stage reveals that this is a relevant instrument, and the magnitude of the coefficient is roughly similar. The only relevant change with respect to OLS can be found in the exploration of mechanisms: once labour and capital are taken into account, the (theoretically unexplained) residual effect of access to markets is still positive with a magnitude similar to that estimated by OLS, but it is only significant at the 10% level.

Finally, the last robustness check is implemented. Throughout the paper, access to markets has been exclusively defined in domestic terms. This approach is justified by the existence of tariffs and by the restrictive trade policy implemented by the Italian government since 1926, aiming at attaining self-sufficiency in many products. Nonetheless, a fully autarkic policy was implemented only after the Italian invasion of Ethiopia and the consequent sanctions of the League of Nations (Ciocca and Toniolo, 1976, Toniolo, 1980). Hence, Italy was by no means a fully closed economy around 1929 and, if demand for agricultural products mattered, international demand may also be taken into account, especially in order to check how the results previously found hold to the inclusion of a broader world. The existence of tariffs implied a distinct treatment for every product according to its origin, and this makes complex the estimation of the effects of international markets. However, a rough approximation can be obtained. I measure access to foreign markets as a weighted by distance sum of population of all cities with more than 100,000 inhabitants in Europe in 1930 and with more than 200,000 inhabitants in 1930 (sometimes in 1935) outside of Europe. Data was collected from the German Statistical Yearbook of 1941-1942 (Statistisches Reichsamt 1942). The resulting measure points out to a higher access to foreign markets in Northern Italy as a whole. With this measure, all the relevant regressions have been re-run and displayed in Table 6. First, access to foreign markets is included as an independent variable along with access to domestic markets (which is the measure used throughout the paper). Access to foreign markets is statistically significant and has a large coefficient. However, the role played by access to domestic markets remains unchanged, both in magnitude and in significance. In column 3 I use also a measure of total access to markets, summing domestic and foreign ones, which results positive and significant as well, with a coefficient higher than that of access to domestic markets alone, as it is reasonable. When the mechanisms are explored, we find that the effect of access to foreign markets on agricultural output vanishes once capital is accounted for (unlike access to domestic markets) but not when labour is individually accounted for. These results seem to suggest that access to foreign markets impacted output through higher inputs of capital but not through higher inputs of labour. Despite these facts deserve further investigation, the role played by access to domestic markets as a key driver in the spatial organization of agricultural production, as investigated throughout the paper, remains unchanged.

5. Conclusion.

This paper explores a simple mechanism for agricultural divergence, in the spirit of Von Thünen models of land use. The case study is Italy in the interwar years, a period during which agricultural output increasingly concentrated in the Northern section of the country. With a detailed cross sectional database on agricultural output and capital, a model for the agricultural divergence connecting output per hectare with access to markets via factor accumulation is tested. The results strongly confirm the predictions of the model. Italian agriculture followed by and large a Von

Thünen pattern around 1930. According to such a pattern, the quest for institutional failures in Southern agriculture is somewhat downplayed. Nonetheless, the insights gained from the foregone analysis suggest some further research. Further quantitative research on Italian agriculture during this period is surely desirable, particularly on the estimation of regional or provincial time series of agricultural output (and possibly capital). While the model presented here is in terms of a single homogeneous product, the original Von Thünen formulation predicts, in a featureless plain, a given succession of crops (determined by product prices and by technical coefficients of production). With some additional research, this side of the model (as well as possible deviations from it) could be explored. There has been also recent focus on the role played by human and social capital in the emergence of the Italian regional divide. While the analytical framework of this paper does not need to factor in such determinants, these explanations are complementary rather than alternatives. After all, human and social capital are factors of production and a closer access to markets can yield higher returns which, in turn, stimulate further accumulation. Hence, the interaction between access to markets and the "intangible" factors of production remains a promising research field. During this period international trade collapsed and hence the importance of access to the domestic market considerably increased. Assessing the relative impact of the drop in external trade on Northern and Southern agriculture remains part of the research agenda. Southern agriculture produced some export products as oil, citrus and wine, and the collapse of the international outlays for this products may have added a non negligible shock to the Southern economy, already disadvantaged by its relatively peripheral position in terms of access to domestic markets. Capital accumulation, as well as internal migrations, may have been shaped at least to some degree by this shock, and this may have had long lasting effects on the Southern economy. All this factors notwithstanding, the advantage of Northern agriculture during this period would be only reinforced by additional research. Actually, this paper shows that it is not surprising that output and factors of production concentrated in increasingly industrialized Northern regions.

APPENDIX.

1. Hierarchy of Italian administrative and statistical levels, interwar years after the 1927 reform.

Administrative or Statistical level	Number
State (A)	1
Region/Circumscription (A)	18
Province (A)	93 (1927-1934/35), 95 (1934/35-1945)
Agrarian Zone (S)	793 (in 1945, with some splits and fusions)
Municipality (A)	7,313 (1931), 7,414 (1945)

2. Data. Italian agriculture around 1930.

There are not ready made data which allow to directly test the Von Thünen hypothesis for Italian agriculture. The available estimates (Federico, 2003) of agricultural output at regional level (18 units in Italy) refer to four benchmark years (1891, 1911, 1938 and 1951). These data are insufficient for the kind of analysis outlined in the previous section, either for the reduced number of available observations or for their very nature. Italian regions are too big units of analysis, they encompass very different environmental conditions and do not allow to actually distinguish between city and countryside. Moreover, any measure of access to markets at such level is bound to somewhat lose meaning. Maybe provinces would be a better unit of analysis, but there are not ready-made estimates at such level. The optimal case would be to have a large panel of small size statistical units. Unfortunately, this is not likely to be available in the coming years. As for some output items (for example, all livestock products) and most of the capital items there are not sources which allow to reconstruct straightforward time series at provincial level, I follow here a different research strategy by relying on a detailed cross section database rather than a more or less flawed panel. According to Federico (2007), even the province (for which some sources do exist) is not a fit unit of analysis for Italian agriculture, whose ideal unit would be the agrarian zone (a statistical level created in 1910). Unfortunately data at agrarian zone level was not regularly published by the main Italian statistical services, and thus poses such problems as to make Federico (2007) to consider "practically impossible" to gather data for carrying on statistical analysis at such a level. There is a single point in time for which detailed statistical information is available at a very low level of disaggregation, namely the "ideal" agrarian zone. This information allows to obtain a cross section of fine estimates for all the required variables, which constitute a new database on Italian agriculture around 1930. With the new database, it is possible to test whether data follow a Von Thünen framework or not. Thus, the research strategy is to test as many predictions derived from the model as possible in a cross-sectional framework. Moreover, the new database allows to gain new insights on the main features of interwar Italian agriculture and its territorial diversity. This allows to uncover many of the aspects usually hidden by figures aggregated at the regional level.

Two big enquiries carried on in the early thirties provide data at agrarian zone level which allow to estimate agricultural output. The Agrarian Cadastre was a gigantic inquiry implemented by the Italian Statistical Institute (ISTAT) reporting data at municipality level, and it was matched in March 1930 with the compilation of a national Livestock Census.

The main source for products of vegetable origin is the Agrarian Cadastre of 1929. It was a massive inquiry aimed at providing a solid base for agricultural statistics. Despite the fact that it was the base of the renewed agricultural statistical service and it has been involved in successive attempts to estimate Italian national income, the extremely disaggregated data of the 1929 Agricultural Cadastre have remained largely unexploited. Researches preferred to use national figures, as their main concern was estimating the long run evolution of the country. Only in relatively recent times Federico (2000) has used it for the first regional estimates of agricultural output before WWII. The Agrarian Cadastre gives, at agrarian zone level, the 1929 output of a large number of crops, as well as their area in 1929.

I have generally followed the procedures (prices, technical coefficients and so on) described in Federico (2000) for the national and regional estimate regarding the year 1938. I have estimated the 1929 output at 1938 prices. The main reason for such a procedure is that the prices of many products are simply unavailable for previous years, since they only started to be collected in 1938. Moreover, this allows comparability with the estimate by Federico (2000) for the year 1938 and with the traditional national series of agricultural real output, computed at 1938 constant prices as well (probably for the same data availability reasons). Such a procedure is not ideal but it seemed to me to be the best among the available ones (as price interpolations), or at least the less distortive given the present stage of the research. In the context of the reconstruction of long run time series, the determinants of the prices of the lacking products should be studied, and then the present estimate could be improved on more solid grounds. Otherwise, avoiding a distortion (using 1938 prices) can lead to a greater and more arbitrary distortion (changing 1929 relative prices by deflating 1938 prices without an informed criterion). Agricultural output is estimated as the Gross Sealable Production. This means that re-uses (as seeds and as feedstuff) may be detracted from the gross output. I estimated the re-uses of some grains as seeds with the technical coefficients (in per hectare terms) in Federico (2000) multiplied by the area of each crop, estimated at agrarian zone level. The only exception to this procedure is wheat, because I took the technical coefficient from the same source pointed out in Federico (2000) but at provincial rather than at regional level (coefficients per hectare are from BMSAF-X, 1934 and are assumed to be the same for the two varieties of wheat). As far as information exists and as far as the aim is to obtain sub-regional level estimates, this seems a reasonable procedure. The 1929 Agrarian Cadastre recorded a large number of crops, but in the provincial volumes the minor ones (which where geographically not very diffused) were included in notes, of heterogeneous shape from volume to volume. This feature makes collecting such data more difficult than those included in the standard table. Moreover, by definition, they are minor ones. Hence, in this estimate I only took into account major products from the standard table. Some items in the standard table were aggregated categories, and the detail of the disaggregation is also given in the notes, so I leave them all for a successive stage of the research.

Wine and olive required a particular procedure, as the agrarian Cadastre only gives data on grapes and olives. The shares of grapes used in wine-producing, the share of wine-grapes used in direct consumption and the share used in direct human consumption have been estimated on provincial basis taking the 1936-1938 average shares (the first available ones), because the Cadastre gives it at agrarian zone only in the notes. This means that the provincial shares have been applied to every agrarian zone belonging to a given province. In a further stage, data could be extracted from the notes in order to produce a further refinement. The yield of grapes in terms of wine has been obtained in the same way. The breakdown between quality and common wines, as well as their relative prices, has been estimated (also on provincial basis) as detailed in Federico (2000). The share of quality wine, in order to compute the value added due to bottling and ageing, has also been computed as the % of DOC wines at provincial level. The share of olives respectively used for oil production and the share used for direct consumption, as well as the yield of olives in terms of oil, has been obtained on provincial basis in the same way.

Some vegetables were reported in the 1929 Cadastre as grouped categories (garlic and onions, cardoons, fennels and celeries). Such figures have been divided according to regional percentages as in Federico (2000). The same regional percentage has been applied to every agrarian zone included therein.

Summing up, the products included in the estimate at agrarian zone level are listed in the following table, along with their Gross Sealable Production and their share on total GSP.

CATEGORY	PRODUCT	GSP 1929 (Million Lire 1938)	% on Total GSP
GRAIN	SOFT WHEAT	6425.4	17.50%
	HARD WHEAT	1892.1	5.15%
	RYE	160.6	0.44%
	BARLEY	60.7	0.17%
	CORN	1218.8	3.32%
	RICE	717.7	1.96%
CITRUS FRUITS	ORANGES	479.2	1.31%
	MANDARINES	54.0	0.15%
	LEMONS	584.3	1.59%
FRUITS	APPLES	541.9	1.48%
	PEARS	325.0	0.89%
	CHERRIES	178.0	0.48%
	PEACHES	430.1	1.17%
	APRICOTS	67.0	0.18%
	PLUMS	74.5	0.20%
	ALMONDS	715.6	1.95%
	WALNUTS	185.5	0.51%
	HAZELNUTS	110.0	0.30%
	DRIED FIGS	54.7	0.15%
	FRESH FIGS	109.3	0.30%
	CAROBS	43.1	0.12%
	QUINCES	6.5	0.02%
	POMEGRANATES	2.1	0.01%
SUGARBEET	BEETROOT	491.8	1.34%
	TOBACCO	229.9	0.63%
	LINEN (FIBER)	0.9	0.00%
	LINEN (SEED)	6.1	0.02%
	HEMP (FIBER)	385.1	1.05%
	HEMP (SEED)	8.1	0.02%
OIL AND RELATED PRODUCTS	OLIVE OIL	2112.6	5.75%
	OLIVES FOR DIRECT CONSUMPTION	52.4	0.14%
	OLIVE RESIDUE	63.9	0.17%
WINE AND RELATED PRODUCTS	WINE VALUE	5080.5	13.84%
	WINE GRAPES FOR DIRECT CONSUMPTION VALUE	247.4	0.67%
	GRAPE FOR DIRECT CONSUMPTION	202.0	0.55%
	DOC WINE BOTTLING VALUE	54.1	0.15%
	DOC WINE BOTTLING VALUE	16.7	0.05%
	MARC VALUE	168.8	0.46%

	DREGS VALUE	14.6	0.04%
PULSES	BROAD BEAN	206.4	0.56%
	BEAN	276.4	0.75%
	PEAS	26.0	0.07%
	LENTILES	17.4	0.05%
	CHICKPEA	58.2	0.16%
	LUPIN	32.8	0.09%
	CHICKLINGPEA	4.2	0.01%
VEGETABLES	COMMON POTATOES	667.5	1.82%
	EARLY POTATOES	154.3	0.42%
	ASPARAGUS	42.2	0.12%
	ARTICHOKES	82.7	0.23%
	CABBAGES	351.6	0.96%
	CAULIFLOWERS	163.9	0.45%
	ONIONS	81.4	0.22%
	GARLIC	53.0	0.14%
	INDUSTRIAL TOMATOES	160.5	0.44%
	TOMATOES FOR DIRECT CONSUMPTION	285.2	0.78%
	CARDOONS	8.1	0.02%
	FENNELS	45.7	0.12%
	CENNERIES	43.0	0.12%
SUM VEGETAL PRODUCTS		26331.6	71.73%

Products of animal origin require their own estimation procedures and a different set of sources. For some of them data availability is a really serious issue, since no data at all is available. I have chosen not to include such products in the present estimate. This is the case of poultry and eggs, rabbits and other minor animals. The animal products not considered by my estimate accounted for a substantial share of production, close to 10% of all gross sealable production. According to Federico (2000), they accounted for 4.166 million lire (at 1938 prices) over 14.322 million lire of all products of animal origin and a total gross sealable production (without forest products and fishing and before detracting expenditures) of close to 45.000 million lire. The main product of this lacking category is poultry and eggs (accounting for more than one third of the whole non-estimated agricultural product), which was still a household activity. This means that my estimate probably underestimates the output of the more densely populated areas with respect to the less densely populated ones. However, additional research on these specific productions will be required.

The remaining products are essentially different types of meat and milk, as well as wool. Unfortunately, data are available for the 1930 year, since the Livestock Census was taken in March 1930. Anyway, assuming that output was the same as in 1929 is not likely to introduce any noticeable bias. The Livestock Census was held simultaneously across Italy in March 19th and reported the stock at that date of the main animals involved in agricultural production, either as an input or as an output. These data were published at municipality level and agrarian zone level. The output has been estimated from the stock as follows. As in Federico (2000), meat production do not include just the animals actually slaughtered, but also potential production due to an increase in the actual increase in stock's weight or to net exports. The average live weight of slaughtered animals was estimated by Federico (2000) taking the first available data (Statistica Macellazione, 1951) at regional level and retropolating it according to the data included in Sommario (1955). I have followed the same procedure. The national change in stock for 1938 has been taken from ISTAT's estimates, as in Federico (2000) and, as there, rearranged proportionally by region (here, agrarian zone). An estimate of the number of animals born has been obtained using the technical coefficients in Federico (2000). The number of animals born minus net imports and the change in stock yields the number of slaughtered animals, to which a weight (different by region) has been given following the aforementioned procedure. The weight of the total stock of each animal category is given (with regional disaggregation) by the ASAI 1936-1938. I have assumed that the average animal being a change in stock or a net import in 1930 had the same weight as the average animal in the total stock of 1938, while the estimated slaughtered animals had a different average weight (computed as explained before).

For pigs, the percentage of sows has been directly obtained at agrarian zone level thanks to the disaggregation by category of the 1930 livestock census, and an estimate of the number of Yorkshire sows (which had a different productivity from the other pigs, in terms both of the number of deliveries per year and in the number of piglets per delivery) has been obtained by multiplying the former by different regional shares. All coefficients (some of them different from region to region, as the number of piglets per delivery of the non-selected races) are, again, from Federico (2000).

For sheep and goats, the procedure and coefficients are also the same suggested by Federico (2000)[4]. Production has been estimated at the same 1938 regional prices as in Federico (2000), in order to allow comparability in real terms.

For cow's milk I have followed the estimate of Federico (2000). First, the number of lactating cows (i.e. the number of cows actually producing milk) has been estimated applying the same fertility and pregnancy coefficients that had been already employed in meat production (95% of the stock of cows has been assumed being fertile, and 90% of the resulting figure has been estimated as being

[4] The only difference with Federico (2000) is that I have used a live weight for sheep and a different one for goats, both from the ASAI 1936-1938 and at regional level.

actually pregnant). Second, a provincial yield per cow has been estimated from the inquiry in Capra, 1938 (BMSAF-IV, 1939), which gave the share of each race in the stock of cows and the yearly production of every race present in every province (with different coefficients per race and province). Thus, a weighted yearly yield has been obtained, and it has been applied to the estimated number of lactating cows. The amount of milk devoted to feed calves has been detracted from the resulting output, computed in per cow terms and published also in BMSAF-IV (1939) with provincial disaggregation. The resulting output, the gross sealable production of cow's milk, has been again decomposed into milk for industrial uses (i.e. devoted to cheese, butter and other derivatives) and milk for human consumption, again with the provincial coefficients estimated in BMSAF-IV (1939). Thus, provincial coefficients of milk for industrial use per cow and milk per human consumption per cow have been obtained. Regional prices have been applied to each of these two categories.

For sheep and goats an estimate of productivity per animal is only available at a regional level (Federico, 2000). It is not known which share of sheep's and goats' milk went to direct consumption and which to industrial uses. In the case of sheep, prices did not differ much (the price for direct consumption being just 17% higher), so a simple average has been computed and used as an overall price. In the case of goats' milk there was no price available at all, and therefore it has been used the one estimated for sheep milk reduced by a 5%.

For wool, the procedure is, again, exactly the same as Federico (2000): it has been assumed that 95% of the total sheep stock was fleeced; the first available regional coefficient of wool per animal (from the early 60s official statistics) has been applied to the resulting figure, and it has been further reduced by a 10% (in order to allow for technical progress between 1930 and 1960). Finally, the national official price has been used.

The value of silkworm cocoons is only available at provincial level (BMSAF-X, 1929). It has been distributed at agrarian zone level proportionally to the output of mulberry leaf (available from the Agrarian Cadastre), and it has been valued at the national official price.

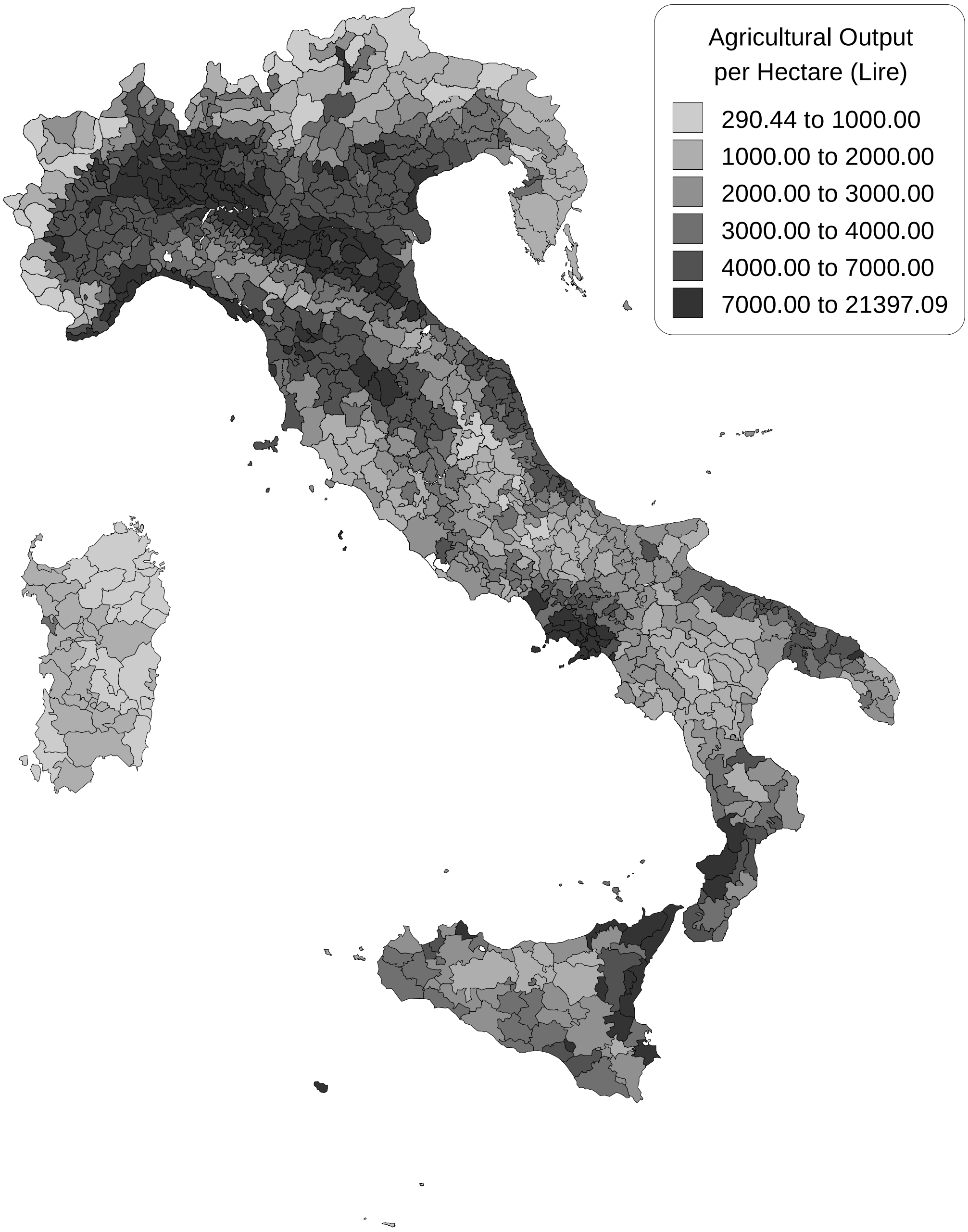
Summing up, the animal products considered are the following.

PRODUCT	GSP 1929 (Million Lire 1938)	% on Total GSP
BOVINE MEAT	2896.72	7.89%
PORK	2405.15	6.55%
SHEEP MEAT	278.51	0.76%

GOAT MEAT	69.37	0.19%
COW'S MILK	3487.93	9.50%
SHEEP'S MILK	230.41	0.63%
GOAT'S MILK	144.27	0.39%
WOOL	319.15	0.87%
SILKWORM COCOONS	546.83	1.49%
SUM PRODUCTS OF ANIMAL ORIGIN	10378.34	28.27%

Their representativeness has been already discussed. They account for 70% of all animal products according to Federico (2000), and for 92% if poultry and eggs are excluded. Vegetable products account for more than 80% of output. As a whole, the present estimate includes a set of products that accounted for 85% of the Gross Sealable Production of the agricultural sector in 1938 as estimated by Federico (2000).

The following map represents output per hectare in 1929-1930.


Agricultural Output
per Hectare (Lire)
290.44 to 1000.00
1000.00 to 2000.00
2000.00 to 3000.00
3000.00 to 4000.00
4000.00 to 7000.00
7000.00 to 21397.09

3. An Estimate of Agricultural Capital in 1930.

Agricultural capital is one of the most difficult magnitudes to estimate in historical (i.e., pre-WWII) reconstructions of national accounts. The scattered nature of agricultural activity, the local specificity of many components of agricultural capital, the non-durability of some other components, all contribute to make uncertain any estimate of capital stock in agriculture for the pre-statistical era. Thus, it is a factor of production rather neglected in historical analyses of the agricultural sector, which are often carried on, at best, focusing only on partial productivities. Estimates of capital in agriculture for some period before 1950 have been only produced for a handful of countries, sometimes going back to 1850 or 1870, and only exceptionally to the beginning of the XIXth century or before (Federico, 2005). Available estimates include Belgium, Canada, France, Germany, Italy, Japan, Russia/USSR, USA, UK and India. Even for this small number of countries, the coverage and quality of the estimate varies sharply. Indeed, most of them usually cover only a limited range of the actual items that, ideally, shall be included in a complete estimate.

The first available estimates for Italy were produced by the so-called Ancona Group, which was working in the reconstruction of the Italian historical national accounts. The results were published in Fuà (1975). They are in the nature of a national time series going from 1881 to 1964 (with estimates of investments going back to 1861), produced by Vitali (1975). Thereafter, the national series was allocated to different territories by Orlando (1975), but only few benchmark data for two broad areas (North and Centre-South) were published. Nonetheless, the series is incomplete in the items considered (for example, the animal stock is not considered at all). Moreover, the methodology employed is sometimes discussable, and indeed has been criticized by Federico (2003 and 2009), who produced his own national estimates only partially relying on Vitali's work. These estimates were first obtained for the year 1911 in order to build up a Social Accounting Matrix for Italy for that year (Federico and O'Rourke, 2000), then they were retropolated in order to estimate the rate of change of TFP in agriculture at national level (Federico, 2003). Both the 1911 benchmark and its retropolation were instrumental to other exercises and were not published. A regional estimate was produced in order to estimate regional TFP in 1911 (Federico, 2007), but was neither published. Eventually, a new national time series was published (Federico, 2009), but it still lacks some items and the author regards it as a provisional one. Summing up, there are some estimates but neither a national complete series of capital stock nor regional estimates (not to say about lower levels of disaggregation) are available.

Vitali's series, which are often used even in the present times, do not hold at any rigorous scrutiny. Setting aside the methodological problems and the rather obscure treatment of some items, the Vitali figures seriously underestimate the capital stock in agriculture by simply lacking so an important item (at least for the period before WWII) as livestock. While this shortcoming is seldom stressed, even a superficial inspection of the magnitudes of the main variables contributes to raise stronger doubts about the traditional estimate. For the year 1938 (for which new estimates of agricultural value added are available), the Vitali's estimate of net capital stock is around 22,400 million Lire (at 1938 prices), with the value of land being of around 180,000 million Lire. On a whole, agriculture concentrated only 5% of the Italian capital stock, while it employed in 1936 something as 50% of population. Moreover, the capital-product ratio in 1938 would have been close to 0.5, an extremely low ratio by all international standards. Despite the limits of the Vitali's estimates and the subsequent quest for new figures by scholars, a disaggregated estimate, either from a geographical or from a categorical point of view, of capital stock in pre-war Italian agriculture is still lacking.

In this section I introduce a new estimate at a level of disaggregation much lower than region (i.e., agrarian zone). It is referred to a single benchmark year (1929-1930) and it has a wider coverage of items than any previous estimates. In successive stages of research, this estimate can serve as a benchmark for a revised national time series of agricultural capital and new regional or even provincial estimates. The general procedure I have followed is to take for each item the most disaggregated data available, either from a geographical perspective or from a thematic one. When data were not available, following Federico (2000, 2003, 2007 and 2009), I have produced an estimate using technical coefficients taken from contemporary sources but, again, the main criterion has been to apply such coefficients to categories of items the most disaggregated as possible. The unit of analysis considered has been the agrarian zone. Data on some items were only available at higher levels of disaggregation and therefore they had to be allocated to agrarian zones according to some criterion. By thematically disaggregating each item, estimation errors were minimized. The most disaggregated a category is, the most a specific criterion is possible to be used in allocating it, and hence the most precise the estimate is likely to be. Moreover, the errors, which without doubt do exist, can be more easily identified, confined to certain subsectors and, eventually, corrected in later stages of research. Here I individually discuss each item and its estimation procedure. The sources and the assumptions made are clearly stated, so the reader is be able to judge the reasonability of every single step by himself. I think that with this procedure the differences and, I think, the substantial improvement with respect to the Vitali estimate can be fully grasped.

According to Federico (2005), the items to be included in a complete estimate of the capital stock used in agriculture, can be grouped in five categories: (i) improvements to land (fencing, terracing, planting tree crops, irrigation works, land reclamation works, etc.); (ii) buildings for agricultural purposes (stables, sheds, granaries, etc.); (iii) tools and machinery; (iv) livestock; and (v) working capital (which includes all the inputs purchased outside the agricultural sector which are employed during a single production cycle and the value of standing crops). Vitali's estimate includes only categories (i), (ii) and (iii), and also the items considered within this reduced set of categories are incomplete. Federico (2009) covers all the categories except (i), which is only partially covered (he actually considers the Vitali's estimate for the sole sub-category of land reclamation). In my estimate I will cover all five categories, trying to include at least the very main items of each category. Further research can allow to include the still lacking minor items.

The following paragraphs are devoted to the discussion of the different sources, strategies and methodologies used.

Irrigation works.

As stated by Federico (2005), irrigation works require huge investments. Despite the fact that the diffusion of irrigation since the XIXth century has been one of the key characteristics of the transformation of Mediterranean agriculture, detailed data are not always available. In the Italian case, the first detailed survey, with data at municipality level estimated following an homogeneous procedure, was only carried on in 1961-1962, and its results were published in Antonietti et al. (1965). Nonetheless, other estimates have been produced at different moments with varying degrees of quality. The first national inquiry on irrigation was commissioned by the government to the marquis Raffaele Pareto in 1865 (Pareto, 1865), and thus it did not include the Venetia (with Mantua) and the Latium, which had not yet been annexed to Italy, as well as the territories annexed after WWI (which were however largely irrelevant from the perspective of irrigation, given their mountainous nature). The author himself raises many doubts about some of the figures obtained (whose data were provided by local government officials). The whole irrigated area in the country was estimated to be 1,357,000 hectares. According to Antonietti et al. (1965), the government carried on two inquiries around 1875 and in 1882, but we have not geographically disaggregated data and we only know that irrigated land was "estimated to be around 1,500,000 hectares in both years". Always according to Antonietti et al. (1965) the government commissioned another estimate in 1900, which yielded the result of 1,650,000 hectares. The estimation methods and the results of this inquiry were so strongly criticized that the government had to carry on a re-estimation in 1905, which resulted in a downsizing of the irrigated area in Italy to around 1,300,000 hectares. This figure is now generally accepted as a measure of the state of irrigation at the beginning of the century. Moreover, this inquiry made available regional estimates. Another estimate, surprisingly neglected by Antonietti et al. (1965) in their historical survey, was carried on in 1931 by the Hydrographic Service of the Italian Ministry of Public Works, yielding 1,442,000 hectares. The published results include data on irrigation with variable degrees of detail (according to the zone considered), but the geographic disaggregation does not match exactly the political boundaries of the time (the river basins being the main unit of analysis). The main aim of the publication was evidently not to supply statistical information, but nonetheless one can extract sufficiently disaggregated quantitative data by digging into it (as only few zones include a summary disaggregated table, and thus a great deal of the data is scattered along the text). Probably the lack of a comparable summary table made Antonietti not to consider it in his review. The following available estimates correspond to a (rough) estimate made by the Land Reclamation Association and some government inquiries afterwards, the one of 1962 being the most accurate. As Antonietti points out, some changes shall be considered more a result of more accurate criteria for collecting the data (which improved over time) than actual changes in irrigated areas; this is especially true for the striking fall in irrigated areas of some regions. For example, it is rather implausible that the irrigated area fell by 15% in Piedmont between 1865 and 1905, and the figures of irrigation of Tuscany, Abruzzi, Basilicata and maybe Apulia in 1865 have to be considered highly overstated.

Hence, as a starting point, irrigated area at agrarian zone level has been estimated from the 1931 inquiry on irrigation (Ministero dei Lavori Pubblici, 1931). The inquiry did not publish something as a summary table with all the quantitative data, so the irrigated hectares must be assigned to the different zones from the river basin tables and, for some areas, from the text. Data at municipality level is sometimes available, and imputation to agrarian zones is straightforward. More often, the inquiry gives data for a group of municipalities; if they do not belong to the same agrarian zone, the total irrigated area has been split according to the arable land or to other ad hoc criteria. Sometimes data refer to broader areas encompassing more than one agrarian zone. In such a case, a guesstimate of the distribution has been done with a case-by-case procedure combining the data on the crop mix from the 1929 Agrarian Cadastre and municipality data from the 1961 inquiry (considering that overhead irrigation is likely to have been totally implemented after WWII).

The inquiry has some contradictions. For the Adda river sub-basin, at p. 184 it is said that there were 145,000 irrigated hectares (and this is roughly the sum of the detailed irrigations in the following pages), whereas at p. 248, in a rough summary of the grand Po basin, the same sub-basin is said to account for 175.000 hectares of irrigated land. Conversely, for the Ticino river sub-basin (contiguous to the Adda's one) the total irrigated area is said to be of "around 100,000 hectares" (p. 190 and 248), whereas the total sum of the detailed channel system (p. 190-192) sums 131,000 irrigated hectares. As the differences between the two basins compensate each other and the agrarian zones included in them partly overlap, I simply have taken the more detailed data as the correct ones.

In some cases, the inquiry does not publish detailed data but gives only descriptive information about the main features of irrigation in a given area. For the Po river basin, this is the case with the sub-basins of the Sesia river and the Dora Baltea river, whose derived channels were interconnected into a huge net organized around the Cavour Channel (which connected the Po from the province of Turin with the Ticino in the province of Novara). This makes hard to attribute the amount of water derived from rivers to one basin rather than to another (one of the main aims of the inquiry), and thus all this area was treated as a single unity, without much detail of individual irrigations. It is only said that the whole area encompassed 170,000 hectares of irrigated land. In the introductory notes of the provincial volume for Vercelli of the Agrarian Cadastre of 1929, data at municipality level of irrigated areas are available. I, thus, have taken these data for this province (in total 91,596 hectares) and the remaining 78,404 have thus been distributed proportionally to the arable land among the municipalities included in the whole irrigation system (spanning five provinces besides Vercelli, the central rice-growing province of the net). For the region of Liguria, the inquiry does not give any detailed data on hectares, except an aggregate data of 12,500 hectares for the whole region (which is suspiciously close to that of the 1905 inquiry). The introductory chapter of the two respective provincial volumes of the 1929 Agrarian Cadastre report 4,118 irrigated hectares in 1930 for the province of Imperia and 6,800 hectares in 1933 for the province of Savona. In 1961 these two provinces accounted for 68.5% of the total irrigated area of the region; if we assume a similar proportion in 1930, the estimated irrigated area turns out to be close to 16,400 hectares. This result, being in between of the 1905 and 1948 available estimates (respectively 12,500 and 22,000 hectares), seems to be rather plausible, and it has thus been assumed as the true one. The area for the provinces of Genoa and La Spezia has been computed as a share of this aggregate estimate, taking the weights of 1961. The resulting provincial data have been divided between coastal and landlocked areas assuming the same respective shares as those of the province of Savona in 1930, the only available ones (with 88.2% of the irrigated areas in the coastal zones), and considering the different weights of coastal municipalities between agrarian zones. Other areas for which the inquiry fails to give any information are the provinces of Pisa and Arezzo (with available data from introductory notes to the respective provincial volumes of the 1929 Agrarian Cadastre, duly diminished because they were published few years after 1930 and irrigation seems to have increased during this period). For Venetia data have been taken from a different source, namely a detailed inquiry on irrigation carried on by the semi-autonomous hydrological authority for the North East (the "Magistrato delle Acque"), because the level of detail and precision of the information therein is much higher than in the 1931 national inquiry: the former systematically includes data on irrigated area at municipality level for the whole area, while the latter does not. For Basilicata and Calabria the inquiry was carried by a local engineer, which reported 10,000 hectares for Basilicata and 50,000 for Calabria. The first result seems a little bit fantastic in comparison with the other available estimates, and has thus been reduced to 8,000.

Combining the aforementioned sources, the estimated irrigated area around 1930, along with the previous available estimates for other years, is distributed as shown in the table.

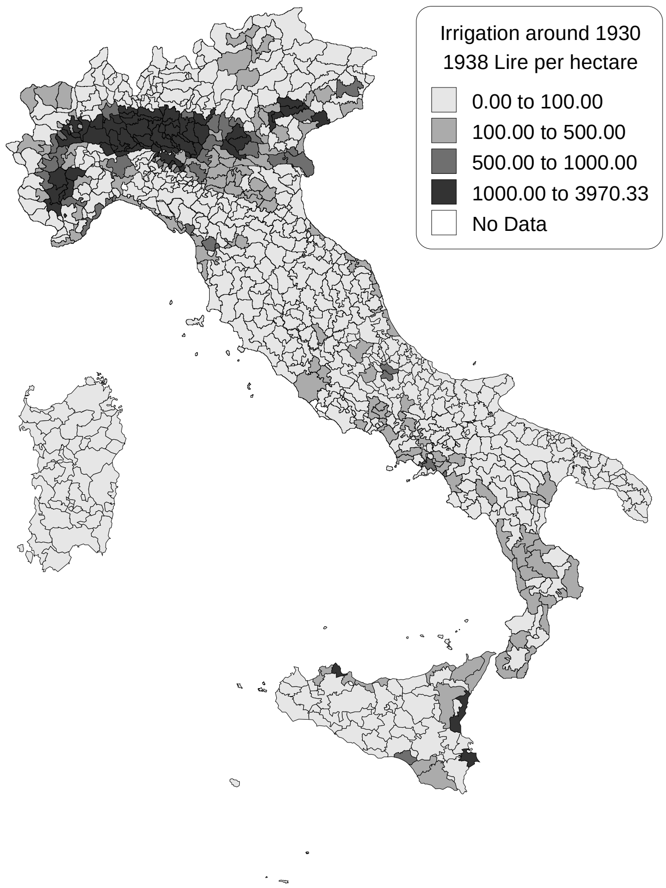
Table 1: Irrigation in Italy (hectares, available estimates and new estimate for 1930)

	1865	1905	1930	1948	1956	1962
Piedmont	406,289	340,724	*361,544*	520,000	523,828	529,454
Liguria	11,250	12,435	*16,366*	22,000	30,780	23,598
Lombardy	646,989	644,513	*542,533*	570,000	674,765	766,247
Trentino-S. Tyrol	NA	NA	*16,637*	23,000	45,404	49,388
Venetia	NA	98,269	*211,167*	415,000	484,476	424,545
Emilia-Romagna	67,904	68,221	*68,240*	290,000	261,048	446,739
Marche	1,649	4,662	*7,603*	15,000	30,776	49,559
Tuscany	32,424	11,960	*21,351*	20,000	43,214	80,304
Umbria	5,803	3,723	*2,450*	12,000	20,020	24,864
Latium	NA	1,000	*29,934*	25,000	80,126	119,207
Abruzzi	31,362	19,590	*18,982*	18,500	27,002	58,017
Campania	38,234	46,025	*22,201*	50,000	84,940	148,707
Apulia	17,442	14,480	*4,556*	13,700	13,129	56,071

Basilicata	18,019	8,164	*8,000*	8,900	6,818	24,171
Calabria	40,168	47,861	*50,000*	52,000	79,072	100,140
Sicily	35,597	35,577	*73,860*	110,000	100,155	163,559
Sardinia	4,502	7,765	*5,574*	20,100	21,020	35,150
Italy (current borders)	1,357,632	1,364,969	1,460,998	2,185,200	2,526,573	3,099,720
Italy (1861 borders)	1,357,632	1,265,700	*1,203,260*	1,722,200	1,916,567	2,506,580

Sources: for 1865, Pareto (1865); for 1905, 1948, 1956 and 1962, D'Atorre et al. (1965); for 1931, Ministero dei Lavori Pubblici (1931) combined with data from Catasto Agrario (provincial volumes) and Carta delle Irrigazioni Venete (1934), as described in the text. Data for 1931 are grouped in regions following the political boundaries (and are thus fully comparable with the other years), unlike in the original source, Ministero dei Lavori Pubblici (1931), p. 83, which follows a basin breakdown system and yields a total irrigated area of 1,442,100 hectares. Venetia includes Friuli Venezia Giulia and Piedmont includes the Aosta Valley.

The cost of irrigation infrastructure is hugely variable, according to specific conditions such as the nature of the land, its slope, the system chosen to irrigate and the pattern of water demand along the year; these variables are also interrelated, so it is not easy to produce a precise estimate. Despite pumping water from the underground (one of the most expensive methods) was a practice already in use in some areas during the period of analysis, it was rather unusual yet. The same can be said about irrigation by dispersion. Niccoli and Fanti (1943) consider the total cost of irrigation infrastructure per hectare in the typical Lombard plain irrigated area of between 2,000 and 5,000 lire. In the province of Alessandria (Zannoni, 1932), the cost of irrigation works for individual farms (mainly through pumping water from the underground) spanned generally from 2,600 to 6,000 lire per hectare, while collective irrigation works in the same province carried on in few municipalities during the same period averaged a cost of 4,600 lire per hectare, with estimated increases in the price of land following investment in irrigation works of 4,000 per hectare (a comparable magnitude). In the 1931 inquiry (Ministero dei Lavori Pubblici, 1931), the whole irrigation system connected to the Cavour Channel is said (without further details on the sources or on the estimation methods used) to have a capital value of 1,200 million lire, i.e. close to 6,700 lire per hectare. Given the conditions of the area (plain area and rather regular supply of water), Lombard (and, in general, the western part of the Po Valley on the left side of the river) conditions may be considered as a lower bound. In the South and in more irregular areas the cost of irrigation works is said to have been much higher. Nonetheless, it is very difficult to apply different costs to the different areas without more information on the local conditions and on the irrigation system used. Taking this into account, considering that (at the time) the bulk of irrigation works was precisely laying in the Po Valley, the average cost per hectare that emerges from sources lays in a range between 4,000 and 4,500. Depreciation should be detracted from the estimate, but then maintenance costs shall be added. As far as irrigation services are kept constant, I have assumed that depreciation and maintenance largely compensate each other, and allowing for some technical progress throughout time (which would made newer works cheaper) I conservatively have set a cost per hectare of irrigated land of 4,000 lire, which is the lower bound of the aforementioned unitary cost range. The result, in per hectare terms, is shown below in a map.

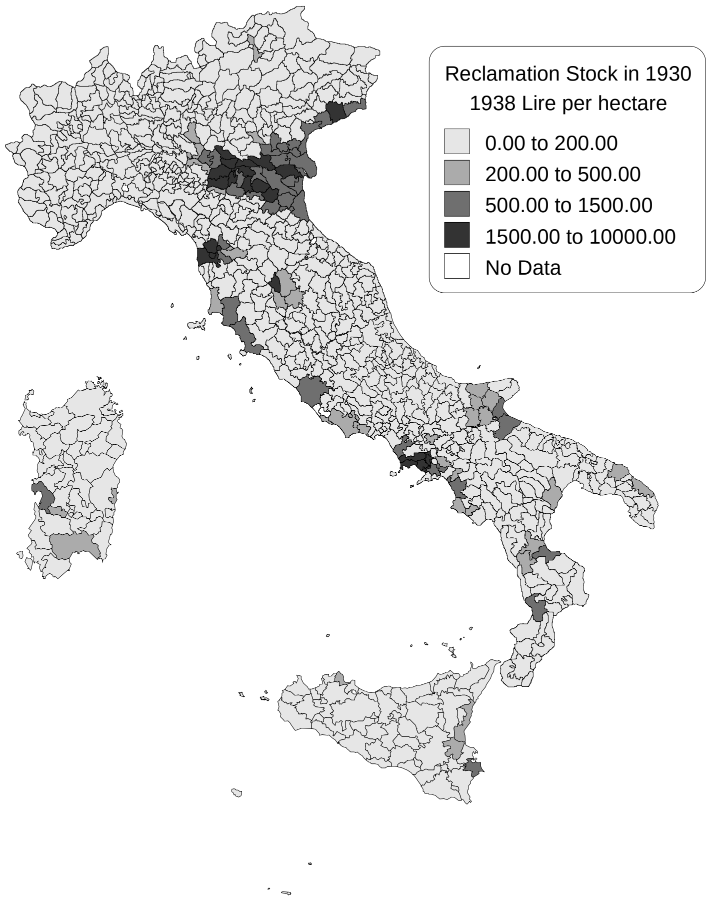


Land Reclamation.

The key source for land reclamation is volume III of the Agricultural Census of 1930, published in 1934. In occasion of the Agricultural Census of 1930, government officials collected data on the area and cumulated expenditure of every land reclamation work in Italy. The volume detailed the municipalities which were included (totally or partially) in a land reclamation authority ("comprensorio di bonifica"), its total area, the area already reclaimed, the area to be reclaimed yet, the starting date of the works, the total cost of the works from their beginning to 1914, from 1915 to 1922 and from 1923 to 1930.

With these data I have estimated the cost (in constant 1938 lire) of every land reclamation work as follows. First, current expenditure has to be converted into constant expenditure, at 1938 prices. In principle, annual series of expenditure for every work should be used, but they are not available. As said, we only know total expenditure grouped into three sub-periods (up to December 1914, from 1915 to 1922, from 1923 to march 1930). I have thus estimated current yearly expenditure flows by simply equally distributing the three expenditure groups between the starting year of every work and the following limit date, and so on for the following periods. Then, the series have been converted into constant 1938 lire by using the ISTAT consumer price index series (ISTAT, 2009). Fortunately, the great changes in the value of the lira match rather well the available breakdown, so no big distortions are expected from this exercise, which remains nonetheless only a rough estimate. In theory, depreciation shall also be included. In practice, I have chosen not to consider depreciation, first because there is no ready-made uniform depreciation rate for land reclamation works (whose features varied greatly with each particular work at hand) and second because I expect to compensate in this way the lack of data on maintenance expenditures. Expenditure data refer exclusively to the cost of the works, which often lasted for decades. A reclamation scheme started in XIXth century would may easily be considered vanished if depreciation is included but maintenance is not, paradoxically yielding the result that a formerly marshland area which in 1930 allowed agricultural activities may be considered as not enjoying “reclamation services” simply because the main works were carried on decades ago, while the ditches and pumps were still there providing capital services. Maintenance costs have to be added to gross depreciation in order to get net depreciation. It is therefore reasonable to assume that, once a reclamation scheme is implemented, maintenance costs matched gross depreciation in order to keep the value of reclamation services (i.e., being able to produce in a marshland) constant.

After obtaining the value of reclamation works in 1930 (at 1938 prices), the total cost has been divided by the total area included in the reclamation work, and then a per-hectare capital-stock-in-reclamation has been assigned to every municipality according to its area within the reclamation area. For the municipalities totally included in the reclamation area imputation is straightforward. The part of the reclamation area not accounted for by municipalities fully included therein has been proportionally distributed to municipalities only partially included in the given area. Municipality data has finally been grouped by agrarian zone. The result is shown below.



The estimated capital stock in land reclamation in 1930 at 1938 prices obtained in that way is 4,099 million lire, which in turn is comparable in magnitude (but nonetheless sensibly larger) than the Vitali estimate of 3,1500 million lire for the same year. The difference may be accounted for by distortions produced by the procedure followed, as well as by the lack of consideration of maintenance costs in Vitali's estimate (and thus his straightforward consideration of gross depreciation as net depreciation). A considerable difference may also be due to differences in the way private investments are included into the land reclamation capital. They were directly included in the inquiry of the 1930 Agricultural Census (used in the present estimate) while it is unknown the procedure followed by Vitali. He says to have somehow "modified" the original aggregate State expenditure series in order to take it into account, without specifying how.

Trees.

The main source for the estimate of capital assets embodied in trees is the Agrarian Cadastre of 1929. The procedure is to take unitary planting costs for every variety of tree and multiply them for the total physical stock. For vineyards, olive-trees and mulberries the procedure is straightforward, as the Cadastre registered for all municipalities the total number of trees per hectare (even distinguishing between up to five levels of productive promiscuity with other crops). For the other varieties of trees the same precise information on the actual number of trees is only available for a half of the provinces. For unknown reasons, from some point onwards the inquirers of the Cadastre decided to start collecting such data on detailed basis, so only provinces whose Cadastre was compiled after that moment have disaggregated data on the number of minor varieties of trees. Until that methodological turn, only the total number of aggregated categories as “citrus trees” and “other fruit-trees” had been collected, without further breakdown. As the cost (and thus the value) of a given orchard is more related to the number of trees (and, thus, to its density) than merely to its area (which is available for all zones), it is necessary to obtain an estimate of the number of trees. Nonetheless, differences in availability of information are limited only to the number of trees, since output and hectares were collected regularly throughout Italy for all varieties of trees. Thus, as a first approximation, I have estimated the total number of trees of the lacking varieties from the output figures at agrarian zone level. In doing so, I have assumed that the zones with incomplete information had the same output per tree ratio than the national average, computed from the agrarian zones for which we have all the data. Despite imprecise, this procedure seems more reasonable than assuming a common density of trees per hectare throughout Italy, the more obvious alternative. In a further stage of the research, the determinants of tree-density for every variety can be studied and a more accurate estimate may then be produced.

I consider the value of an orchard equal to the unitary cost of planting its trees, comprehensive of all the expenditures incurred until the tree reaches the beginning of its productive live, valued at 1938 prices. For estimating the unitary cost, I rely on agronomical handbooks of the time, as Niccoli (1898 and 1900), Niccoli and Fanti (1943)[5], Tassinari (2nd ed., 1945) and Tamaro (1915), as well as on some contemporary studies on actual farm improvements and investments on land melioration carried on by the INEA (“Studi su trasformazioni fondiarie” and “Monografie sui comprensori di Bonimica”) and by other scholars (Petrocchi, 1927). I have collected as many unitary costs as possible and then a simple average has been made. All prices have been transformed into 1938 prices by simply using the general consumer price index (Istat, 2009). The coefficients finally used are listed in the following table.

	Average cost per tree
Vines	2.97

[5] Niccoli and Fanti (1943) is the 14th edition of Niccoli (1898), so using both of them allows to evaluate the changes in relative prices and techniques during the period.

Olive-tree	49.56
Orange-tree	37.14
Mandarin-tree	35.81
Lemon-tree	34.47
Other-citrus	35.81
Mulberry-tree	19.09
Apple-tree	3.68
Pear-tree	3.68
Quince and Pomegranate-tree	3.68
Peach-tree	54.82
Apricot-tree	4.37
Plum-tree	4.37
Cherry-tree	6.21
Almond-tree	6.9
Walnut-tree	3.79
Hazel-tree	0.68
Fig-tree	3.68
Carob-tree	3.68

These procedures, as well as others used here (as the estimation of the cost of some varieties of trees whose price is not available through the cost of similar trees and the use of the same price throughout the country) are far from optimal; further research, possibly relying on local or regional studies, is desirable in order to substantially improve the precision of the estimate. Nonetheless, as a first approximation, the orders of magnitude of the true values are probably not very far from the ones used here. The gross values thus computed have been reduced by a 50% in order to take into account depreciation.

Terraces.

In some circumstances the cost of planting a tree represents only a part of the capital embodied in orchards. In many areas of the country tree-crops were grown in steep hillsides which required additional investment in preparing the land and making it suitable for growing vines or other trees. It is hard to value the cost of these works, which vary with the composition and slope of the terrain. Every estimate of such expenditures is necessarily a guesstimate. Nonetheless, these works had been done, and a mere estimate is better than nothing. According to Niccoli and Fanti (1943), the standard cost of terracing, ditching, building rural roads, etc. in hillsides can be estimated as being around 3,000 Lire per hectare. In extreme cases, the cost could reach 6,000 or even 10,000 Lire per hectare, as was the case with the very intensive citrus production around Naples (Amalfi). Nevertheless, only the most remunerative productions could justify such costs, which may be considered an absolute upper bound and as such rather far from the average. According to Colombo (1926), a man with a spade was able to remove between 10 and 30 squared meters of earth (depending on its composition and toughness) in an hour. Considering that the male agricultural hourly wage ranged in 1938 Italy between 1.03 and 2.43 lire (and averaged something as 1.4 lire per hour), the cost per hectare (which consists of 10,000 squared meters) of simply removing earth had to be between 1,000-2,400 Lire for hard soils and 333-800 Lire for soft soils. Taking into account that removing land is just one of the operations involved (while many of them can be assimilated to it), the figures of Niccoli and Fanti (1943) seem rather plausible. Their standard figure may be somewhat reduced for depreciation (some of this work has to be done again earlier or later, and maintenance has to be accounted for), but then cleaning the land and cutting trees (necessary for turning productive every hectare of original virgin land) has also to be included in the estimate, as well as building walls and water drainage works. Summing up, 1,400 Lire per hectare seems a reasonable guesstimate of the average cost of terracing for hillside orchards, to be added to the standard unitary cost of planting a tree. Unfortunately, we do not know exactly how many hectares of terraces were in every agrarian zone. A very bold estimate has been done in the following way. First, the share of plains and hills of every agrarian zone has been computed. The Agrarian Cadastre of 1929 reported for every municipality the absolute maximum and minimum altitudes, as well as the maximum and minimum altitude between which the prevailing area of the municipality was laying. The latter seems to be a better proxy for the slope of agricultural terrains than the former, as outliers or sterile rocks in high mountain municipalities are excluded. If the difference was less than

50 meters, I have considered the area as totally plain, if it was above 200 meters, I have considered it as totally hilly, while if it was something in between I have divided the shares of plain and hilly land by linear interpolation (with 125 meters of difference in main altitudes representing 50% plains and 50% hills). By adding these estimates of hill and plain areas at municipality level I have obtained estimates at agrarian zone level. I have assumed that tree-crops were uniformly distributed between plains and hillsides. Then, the hectares of terraces have been estimated as the product of the share of hillsides in the total area of the agrarian zone and the number of hectares with tree-crops. The procedure implies assuming that the share of orchards in terraces within a given agrarian zone was equal to the share of the estimated hilly area within the agrarian zone. Finally, the unitary cost has been applied.

Non-residential buildings and structures.

As there were not statistical surveys on non-residential buildings and structures, I have estimated their quantity from the demand side. As for trees, I have relied on agronomical handbooks (Niccoli, 1898, 1900, Niccoli and Fanti, 1943, Tassinari, 2nd ed., 1945), as well as on Colombo (1926) and Colombo (1947), the “Bible” of Italian engineers. The main difficulty here has been to distinguish between the part of rural dwellings that was agricultural capital and the part that was part of the housing stock, because usually peasants lived in the same building where they worked and the distinction may be artificial. I have followed the procedure of obtaining an estimate of the agricultural building stock from the demand side based on volumes, and then estimating its cost. This procedure is likely to be more precise than estimating the demand in per hectare terms or in terms of the size of the farms. Some costs per cubic meter for different types of rural buildings can be found in the cited handbooks. They actually turn out to be comprised within a surprisingly narrow interval (between 30 and 55 pre-WWII Lire per cubic meter for whole farms), probably pointing out that there were very small economies of scale in the construction of rural buildings: if you double your herd, you simply build another stable; at the end of the day, a bigger stable represents just a wall saved, which does not seem to have been very much in relation to the cost of the whole building. Moreover, other sources from actual farms and rural buildings (combining in the same structure agricultural productive areas and housing areas) built during the late 20s and 30s (Nuove costruzioni rurali, 1929, and the volumes in the series Studi su Trasformazioni Fondiarie) confirm a cost of around 50 Lire per cubic meter. Niccoli and Fanti (1943) suggest a destination-based cost per cubic meter: 70-90 Lire for housing, 80-100 for stables and cattle-sheds and 30-60 for sheds. As an average of these elements for whole farms, they propose a cost of 50-60 Lire per cubic meter for medium-sized cottages and 60-80 for large complexes with substantial product transformation. In both cases, the cost is slightly higher than actual farms data (but this may simply reflect a theoretical best-practice standard), while the order of magnitude is comparable with the actual farm data available. As these figures may reflect the cost of building new farms, the actual average value per cubic meter may have been around 30 lire (a rather lower bound) if we have to consider depreciation and a lower value of older brands of materials. Nonetheless, it is likely that the unitary cost of the housing area of rural buildings was something higher than the whole average cost (for better materials used therein and for including more complex services), so it seems reasonable to assume a cost of 60 lire per cubic meter for stables and cattle-shed, a cost of 30 Lire per cubic meter for sheds, granaries and barns, and 10 Lire per cubic meter for manure depots (computed considering different technical coefficients form Niccoli and Fanti, 1943, and Colombo, 1947).

The volume of stables has been obtained from technical coefficients. Coefficients used are the average of those found in Tassinari (1945) and Niccoli and Fanti (1943), with specific animal-type and age values. The volume of manure depots has been computed multiplying the stock of animals of every age group and economic use (draught, milk production, meat production) by a coefficient of yearly production of manure per animal (considering that different uses implied differences in the possibilities of stocking the manure produced in the depots). The weight of manure has been transformed into volume assuming a weight of 400 kg per cubic meter: according to Niccoli and Fanti (1943) this ratio corresponded to an average ageing of manure, whose weight per cubic meter increased with time from 200 kg to 700 kg. Each cubic meter of manure depot is considered to have been able to contain on average 1.7 cubic meters of manure (Colombo, 1947).

The coefficients used are the following:

	m^3 per unity	
	STABLES	MANURE DEPOTS
Horses (<3 years)	18.75	10
Horses (>3 years)	28.125	15
Donkeys and "Bardotti"	20	10
Mules (<2 years)	18	5

Mules (>2 years)	20	10
Buffalos	25	15
Veals (<1 year)	8	15
Young bovines (1<years<2)	10	15
Bulls (> 2 years)	15	20
Oxen	25	25
Milk cows	23	30
Common cows	21	22
Pigs (<6 months)	2.45	1
Pigs (6<months<12)	3.85	1.5
He-pigs, reproduction (>1 year)	8	5
She-pigs (> 1 year)	6	5
He-pigs, meat production (>1 year)	6.7	5.2
Lambs	2.6	0.5
Rams, muttons and sheep	4.4	2
Wethers	3.2	2
Goats (<1 year)	2.6	0.5
Goats (>1 year)	4.4	2

For granaries and barns, the demanded volume has been estimated as a function of the average yearly output between 1923 and 1928 (available at agrarian zone level from the Agrarian Cadastre), duly transformed from quintals into cubic meters (the transformation coefficients for each product have been taken from Niccoli and Fanti, 1943), increased by a 10% to allow for some excess capacity, and then again increased by a 20% to take into account the irregularity in the distribution of space and some additional space needed for doors, operating transportation machinery, stairs, etc. Wheat and other cereals, as well as pulses, potatoes, industrial crops and hay-equivalent fodder are included in the calculus. The hay-equivalent output of meadows in rotations is considered by a 75%, while only 25% of the output in permanent meadows is included (to account for the shares directly consumed on the ground and not stored).

For wine-processing equipment, Niccoli and Fanti (1943) point out a value of around 30 Lire per hl, which roughly matches the average value per hl of wine produced recorded in a set of studies on peasant families carried on by the INEA during the 30s which occasionally included the quantity and value of agricultural capital items with enough detail to allow an estimate ("Monografie di Famiglie Agricole", various years). This figure is of a magnitude comparable to the coefficient used by Federico and O'Rourke (2000) (which would have resulted in something above 40 Lire per hl at 1938 prices), who already include depreciation in their estimate. The slightly lower value adopted may capture technical progress between 1910 and 1930. For olive-oil processing I have assumed a similar technical progress and thus I have employed a coefficient of 65 Lire per hl. Furthermore, 40 Lire per hectolitre has been used as a coefficient in order to estimate wine-processing and olive-processing facilities. All these wine and oil-related capital stock items have been estimated from the demand side using the 1923-1928 average output, increased by a 10% in order to leave some room for excess capacity along the cycle (necessary for being able to process all output in peak years).

Livestock.

The value of livestock is simply the sum of the product of the stock of each type of animal (in kg) by its price. The introductory notes to the Livestock Census of 1930 report an estimate of the value of livestock. Despite data on prices are said to have been gathered at local level from a variety of sources (such as markets, often at sub-provincial level, farmers' registers and veterinaries for animals without a regular market), and thus may have been of high quality, not further information is given on this point and data on prices were not published. Furthermore, the only table published on the issue reports the value of aggregated categories (equines, cattle, pigs, sheep and goats). Moreover, data on livestock value were published only at agrarian region level (which is broader than agrarian zone, my benchmark level of analysis). Thus, livestock value data of the Census can not be directly used, though it may be a useful standard for comparative purposes.

Average 1938 prices for all the different type and age profiles (with exception of equines) of animals are available, for different markets, in ASAI 1936-1938. Prices refer to units of weight, so a measure of the differences in weights is needed. For weights I have taken age-specific and use-specific weights from the first year in which slaughtering statistics were compiled on a national base, 1949, from ASAI 1947-1951. There are available statistics at provincial level with age-profile breakdown for 1939, but only about animals slaughtered in municipalities over 10,000 inhabitants, and the use of these data requires further research in order to avoid any possible bias. Equines represent a problem, because data on its price and weight are very scarce. Indeed, ASAI 1936-1938 does not report prices for any market of these animals. Due to the reduced consumption of meat of horses, donkeys and mules it is also likely that the animals slaughtered are less representative of the actual stock than any other variety of animal slaughtered. For horses, mules and donkeys the only available price for 1938 is from the foreign trade statistics, which may not be fully representative due to the reduced number of animals traded (4,884 horses, 116 donkeys, and 272 mules imported in 1938). Indeed, the resulting price is 2,870 Lire per horse, 155 per donkey and 1172 per mule, which seems a little bit odd (especially the difference in prices between donkeys and horses). The price of horses also seems to be higher than the one occasionally recorded in the aforementioned INEA's inquiry on peasant families (usually around 2,000-2,500 Lire). Moreover, foreign trade statistics report imports of equines in per caput terms rather than in per kg terms, and thus it is not possible to capture differences in the composition of stock by age or by use (i.e., draught animals or reproduction animals). However, applying the per unit prices of foreign trade statistics to the aggregate stock of each species, a total value of 3,390 million of Lire in equines has been obtained, 15% higher than the Livestock Census' estimate of 2,927 million Lire (the general level of prices differed only by 1% between 1930 and 1938, and then the figures are fully comparable). This result seems to be rather strange, given the fact that between 1930 and 1938 the number of tractors in Italy rose by a 50% and the price of oxen, the natural alternative candidate for draught works to equines and tractors, fell by a 6-7% (Sommario, 1958). Intuition suggests that the relative price of horses may have fallen, and thus the equines' stock in 1930 valued at 1938 prices is unlikely to have been greater than the same stock valued at 1930 prices. All these elements point out that the prices of horses from foreign trade statistics could be somewhat misleading if used as a proxy of the price of the whole stock of equines. So another way has to be pursued. There are price data for 1928 on equines with age and use breakdown for the North-Eastern province of Vicenza (Ferrari, 1931), which may be used as a check. The level of prices in 1928 was a 99,29% that of 1938 and essentially equal to that of 1930, so all the values are comparable in real terms. Prices are also in per caput terms. Assuming these specific prices[6] the value of equine stock is astonishingly close to the one reported by the Livestock Census (3,082 million Lire as against 2,927). Also the composition of this value seems to be more plausible than the one obtained with straightforward use of foreign trade statistics without any regard to the age and use profile: 940,000 horses of all ages and uses (out of a total of 2.3 million equines) account in the latter case for 79% of the total value, as against a more plausible 59% of the former. Lacking better alternatives, I have adopted the per caput prices reported in Ferrari (1931) for equines, reduced by a 6,5% to take into account the changes in real prices of draught animals (assuming a fall in prices equal to that of oxen).

Machinery.

There are not data at agrarian zone level on machinery and tools, so all available data must be assigned to an agrarian zone according to some criteria. The stock of tractors in 1929 is available at provincial level from UMA (1968). Data include the number of foreign tractors and their respective power, in HP. While Italian-made tractors were systematically more powerful than foreign ones (around 30% more HP per tractor in Northern provinces and 20% more in Southern ones), there is no evidence of systematic differences in prices, ceteris paribus. 1939 Prices of 14 types among the most common tractors are available from Tassinari (1945). This source also include other characteristics of the models, such as Horse Power, the producer company, if they were caterpillar tractors or wheel tractors, and if they worked with oil or with naphtha. Despite the reduced degrees of freedom, when prices are regressed on this variables all turn out to be statistically significant except their "Italianity". This is absolutely reasonable: in equilibrium there should be a single market price irrespective of the relative market shares of domestic and international producers, which are determined by differences in the production functions, transport costs and duties. Anyway, the price dataset in Tassinari (1945) turns useful to estimate the value of the stock of tractors. Using the coefficients of the regression, and assuming that 2,5% of the tractors worked with naphtha and 5% were caterpillars, one gets a value of 702 million Lire, and assuming that the respective shares were 0,01% the value of the tractor stock is 658 million lire. The former is the same as assuming a unit price of 33,300 Lire (1939) per tractor, which fits rather well with the available set of prices (spanning from 18,000 to 68,000, with two outliers above 100,000). The only two models whose price is given in the official agricultural statistics yearbook for the years 1939-1942 (both Fiat) have prices of 29,625 and 47,417 Lire (ASAI, 1939-1942). The assumed average

[6] Ferrari (1931) reports 800 Lire for young horses, 6,000 Lire for stallions, 2,500 Lire for brood mares, 1,800 Lire for workhorses, 500 Lire for donkeys and 2,000 Lire for mules and hinnies. Assuming stallion-work animal and young animal-work animal price ratios similar to those of horses, the price for donkey stallions and for young mules can be estimated, respectively, as 1,667 Lire and 889 Lire.

price is roughly in the middle of the lower half of the available price range. Thus, this value has been considered as the correct one and has been reduced in order to take into account depreciation (a 5% seems reasonable given the recent introduction of tractors in Italy) and inflation between 1938 and 1939. The final result is a total net value of the capital stock in tractors of 639 million of Lire, which alone accounts for close to one half of the Vitali's estimate of tools and machinery in 1929 (1,4 million Lire). The provincial values thus obtained have been distributed among the agrarian zones in proportion to their arable land (excluding pastures and trees).

The Italian Statistical Office started collecting and publishing in its agricultural bulletin (BMSAF, ad annum) data on threshers in 1928. Provincial data are thus available for 1929. Provincial data have been assigned to agrarian zones according to the 1929 output of cereals in quintals (excluding corn), in order to capture the fact that, given similar crop areas, differences in yields are likely to lead to differences in the demands for the services of threshers. As some threshers moved around according to the demand for its services, the input of capital in threshers is assumed to be proportional to the 1929 output rather than to the 1923-1928 average. Corn shellers, the corn-equivalent of threshers, were first counted, also at provincial level, in the 1937-1938 Industrial Census, along with threshers. The first available year reported is 1936. I have estimated the provincial number of shellers in 1929 assuming that the provincial ratios of shellers to threshers were stable between 1929 and 1936. Corn shellers have been distributed among agrarian zones proportionally to the 1929 corn output. There is much less information available for pricing threshers, as no data beyond its number is available for 1929. The price range of the five models in Tassinari (1945) is similar to that of tractors, spanning from a minimum of 18,000 to a maximum of 65,000 Lire. The agricultural statistics yearbook for 1947-1950 reports only one price for threshers, and it was 7% lower than the price of a tractor of 28 HP (the average tractor in 1929 had 27 HP). Hence, I have assumed a value of 30,000 lire as a fair guess, conveniently reduced again by a 5% to take into account depreciation and a similar deflator for including the effects of inflation between 1938 and 1939. Corn shellers' prices are even more hard to find, and indeed the only available is 10,000 Lire in Tassinari (1945). I have adopted a price of 8,000 Lire, further reduced as threshers.

Other oil engines for agricultural use are also available from UMA (1968), with the total number and the total horsepower at provincial level. Tassinari (1945) reports three models with their respective prices, and the fit of a regression of the prices on the HP is almost perfect, with an r-squared of 0,98. The intercept is 1,500 Lire, which increased by 571,4 Lire for each additional HP. These coefficients have been used to estimate the value of the motors. The provincial value of motors has been distributed among agrarian zones proportionally to the sum of the value of tractors, threshers and corn-shellers, which is assumed to have been a good index of the overall level of mechanization of the agriculture of each agrarian zone.

The total value of these items is 1,399 million Lire (1938 prices), almost identical to the 1,39 million Lire of Vitali's estimates of machinery and tools for 1929. Nonetheless, in the present estimate other machines and small tools have not been included. There is only partial and scattered evidence on the amount of other minor machines as well as on smaller instruments and tools from a variety of sources. At a first glance, a case-by-case approach can be followed, collecting the evidence on the lacking items, generally from provincial studies or from study-cases (peasant families' inquiries and similar works), and then extrapolating the available information of every particular item with an informed criterion. Nonetheless, at the present stage of the research this is not possible. Considering the similarity of the order of magnitude obtained with that of Vitali's estimate, the lacking items may not account for a gigantic part of the total stock of tools and machinery.

Working capital

The Italian statistical office started publishing data on the fertilizers distributed at provincial level (including the imported ones) in 1931, but the first available data fortunately refer also to 1929. However, data underwent revision, and the definitive figures are taken from the February issue of the agricultural statistical bulletin (BMSAF, February 1932). Prices have been taken from ASAI 1936-1938, and the quantities of fertilizers have been distributed proportionally to the sum of the arable land and the tree crop land. The only available data on pesticides are referred to copper sulphate at regional level for the financial year 1929-1930 (which has been assumed as being equal to the consumption of 1929); these data have then been valued at 1938 prices (ASAI 1936-1938) and distributed among provinces proportionally to the expenditure in fertilizers; thereafter, again, they have been distributed proportionally to the arable and tree land area among agrarian zones. For fuel consumption, data on oil consumption for agricultural purposes at provincial level is available from UMA (1968). I have distributed it among agrarian zones proportionally to the estimated value of machinery.

Conclusion.

The value of the agricultural capital stock resulting from the present estimate, 66 million Lire, is almost five times the Vitali's estimate for the same year (13.5 million Lire), valued also at 1938 prices. His category "land improvements" includes at least the sum of irrigation, trees and structures (and even rural dwellings, which are not included here and which constitute double counting in

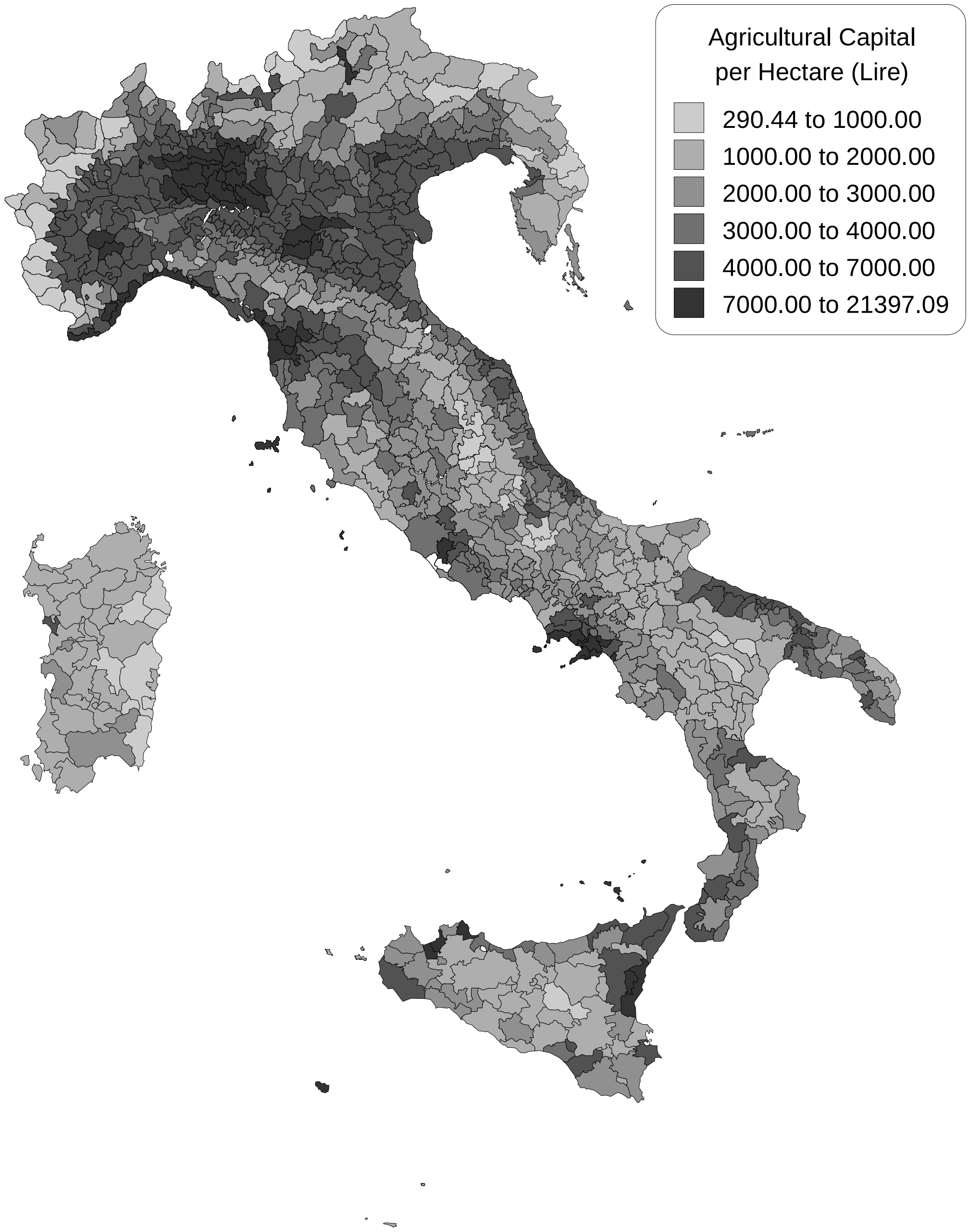
Vitali's series), and it is not clear if initial works are included. Anyway, they sum 11,3 million Lire. Even dropping totally the value of structures and of initial works (by construction, the most uncertain items of the present estimate), irrigation and trees alone account for the entire Vitali's estimate. Initial works and structures may have been somewhat misallocated, but their estimated value is seemingly to be of the same order of magnitude of the actual one. Despite the value of trees could only be more accurately ascertained by means of the reconstruction of the long-run series (because the level of depreciation depends on the trend of total acreage), it is very probably underestimated (the depreciation rate of 50% used is so high that would entail no new investments in keeping the tree stock constant over time). Also irrigation is surely underestimated. Machinery is surely underestimated, because additional machines existed and are not counted here. Livestock refers to the value at the beginning of 1930, but no great changes are expected. Working capital also underestimate minor intermediate inputs, as electric energy and the value added generated by the seed processing industry (a payment form agriculture to other sectors). The general picture and the relative importance of every item can be better grasped from the following table.

CAPITAL ITEM	NET VALUE in 1929-1930 (Million 1938 Lire)	Share
RECLAMATION STOCK	4,098.81	6.17%
IRRIGATION INFRASTRUCTURE	5,844.00	8.80%
TERRACING, HILLS	2,176.97	3.28%
TREES	16,128.84	24.29%
TRACTORS	638.38	0.96%
THRESHERS	706.90	1.06%
CORN SHELLERS	37.84	0.06%
OTHER MOTORS FOR AGRICULTURAL PURPOSES	15.22	0.02%
STABLES	14,228.83	21.43%
MANURE DEPOTS	1,250.01	1.88%
BARNS	1,019.26	1.54%
HAY LOFTS	1,837.24	2.77%
WINE-EQUIPMENT	1,604.89	2.42%
OIL-EQUIPMENT	184.92	0.28%
WINE FACILITIES	2,139.86	3.22%
OIL FACILITIES	113.80	0.17%
FERTILIZERS	905.78	1.36%
OIL CONSUMPTION	61.15	0.09%
SULPHATE	152.18	0.23%
LIVESTOCK	13,256.22	19.96%

TOTAL AGRICULTURAL CAPITAL	66,401.10	100.00%

The present estimate of agricultural capital stock is not to be considered definitive yet. Many refinements are possible and including estimates of some lacking items is highly desirable. Particularly, the use of region or even province-specific coefficients are desirable in order to capture differences in building materials, prices of inputs and agricultural practices. The same can be said on the need to better take into account the different nature in terrains, and hence in the cost of some works. Further items will in the future be added to the already existing categories (particularly to machinery and working capital). This research is likely to shape the value of some items. Nonetheless, the main picture seems to be already reasonably clear. The allocation of irrigation, reclamation, livestock and trees among agrarian zones is particularly accurate. Italian agriculture was a much more capital-using sector than traditional estimates suggest. It employed in 1929 no less than 15% of the national capital stock, as against previous estimates of less than 5%; probably the total share was close to 20%, excluding rural dwellings. Over two-thirds of this capital was fixed in land. The northern part of the country (that lying above an imaginary line from La Spezia to Pesaro) accounted for more than half of the capital in agriculture of the whole country, while it just accounted for less than 40% of total land.

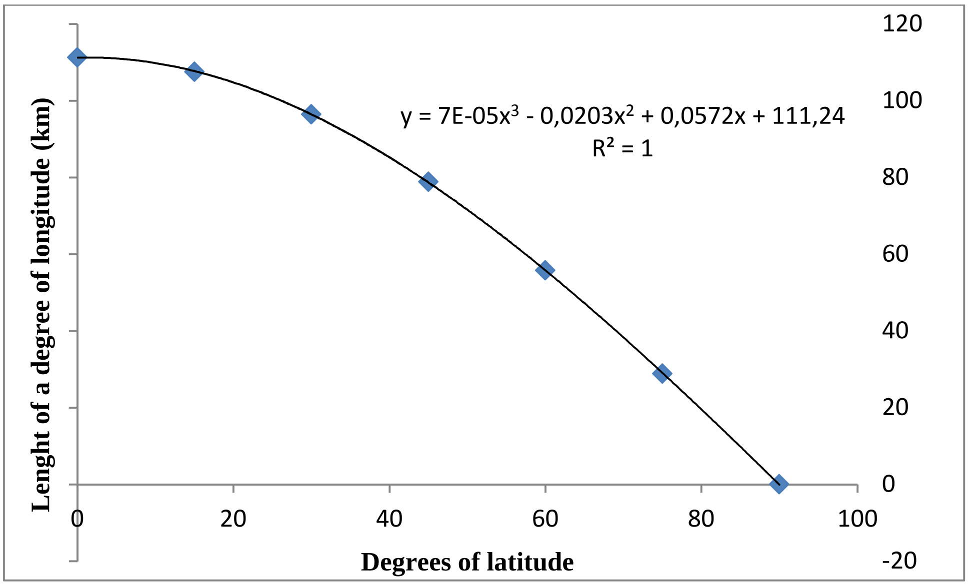
Nonetheless, all the main categories have been taken into account and the general picture is hardly going to be substantially reshaped by further research. As a matter of fact, the estimate presented here is much more complete in the coverage of items than the Vitali’s one and by far much more disaggregated at geographical level. The resulting geographical pattern of capital in agriculture in per hectare terms throughout Italy can be fully appreciated in the following map.



4. Adjustment procedure for coordinates: from degrees (variables in length) to kilometres.

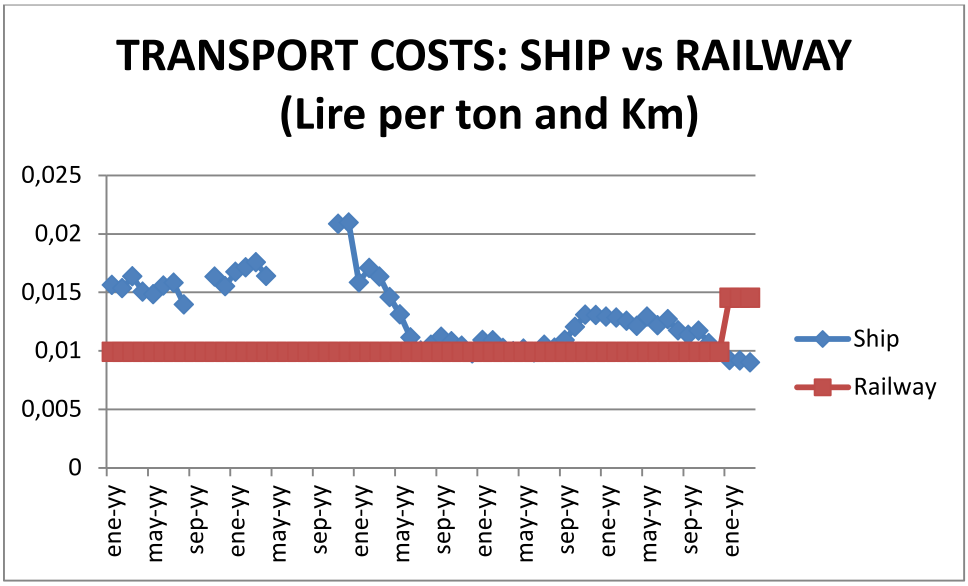
The conversion procedure is made assuming a constant length of 111.24 km for a degree of latitude, which varies only marginally from a minimum of 110.574 km at 0 degrees of latitude to a maximum of 111.694 km at 90 degrees of latitude. For longitude, a function relating length in km of a degree of longitude and degrees of latitude is interpolated from some known values of the two variables at some characteristic degrees of latitude (0, 15, 30, 45, 60, 75 and 90 degrees), as shown in the figure. The resulting polynomial is used to transform every location's coordinates in degrees into coordinates in distance in kilometres from the Equator.

Graph 3: Relationship between the length in km of a degree of longitude and degrees of latitude



5. Transport costs in late 1920s Italy.

Railway rates were fixed by the government and were kept constant throughout the period considered, until an increase took place in 1930. Railway transport cost refers to the cost of shipping 15 tons of coal at a distance of 100 km, the only distance reported in ISTAT (1955). Railway rates changed according to the distance involved, and the one for 100 km can be considered an upper bound (as rates decreased with the distance involved). Dividing the rate by the number of tons and the number of km we get the unitary cost per ton and km. Ship transport costs within Italy were not reported regularly in any publication, as far as the author knows. The Monthly Statistical Bulletin published since 1926 by the Italian Statistical office (BMS, ad annum) reported freight rates (in British pounds) for shipping one ton of coal from Bristol to Genoa, as well as the monthly exchange rate of the Italian Lira and the British Pound. Considering that such a distance is close to 3,500 km, these information allows to compute the monthly transport cost in lire per ton and kilometre between Bristol and Genoa, which is likely to have been a lower bound if compared to the (unknown) freight rates between any pair of Italian ports (surely closer than 3,500 km). This cost is fully comparable with the rate fixed by the State for railways. As far as the cost for railway considered is an upper bound while the cost for ship is a lower bound, the relative cost for 1km by railway is likely to be somewhat overestimated in the present comparison. Even in this case, the two alternatives seem to have been of the same order of magnitude and, if anything, ships seem to have been slightly more expensive than railways during this period. Of course, our interest is not in whether an agent chooses a ship or a train to ship its commodities (obviously ships allow to save in distance in most cases). The interest here is in unitary prices. The focus is in assessing if we are introducing substantial distortions by considering one kilometre by water as roughly comparable to one kilometre by land. In view of the data, we shall conclude that no large biases are introduced by the use of inverse weighting distance, and that, if anything, the direction of the bias overstates the access to markets of, say, Palermo in comparison with that of, say, Milan.



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SUMMARY STATISTICS					
Variable	Obs	Mean	Std. Dev.	Min	Max
Agricultural Output per Hectare	793	7.352	0.662	4.618	9.315
Access to Markets 1 (Total Population)	793	12.108	0.286	11.003	12.947
Access to Markets 2 (Agglomerated Population)	793	11.807	0.261	10.785	12.813
Access to Markets 3 (Agg. Pop. Municipalities>10,000)	793	11.077	0.287	10.094	12.562
Access to Markets 4 (Non-Agricultural Families)	793	10.077	0.338	8.977	11.259
Access to Markets 5 (Non-Agricultural Individuals)	793	11.414	0.328	10.321	12.594
Piedmont Dummy	795	0.098	0.298	0.000	1.000
Liguria Dummy	795	0.029	0.168	0.000	1.000
Lombardy Dummy	795	0.107	0.309	0.000	1.000
Trentino S.T. Dummy	795	0.019	0.136	0.000	1.000
Venetia Dummy	795	0.069	0.254	0.000	1.000
Venetia Julia Dummy	795	0.025	0.157	0.000	1.000
Emilia Dummy	795	0.077	0.266	0.000	1.000
Tuscany Dummy	795	0.068	0.252	0.000	1.000
Latium Dummy	795	0.063	0.243	0.000	1.000
Abruzzi Dummy	795	0.078	0.268	0.000	1.000
Campania Dummy	795	0.059	0.236	0.000	1.000
Apulia Dummy	795	0.067	0.250	0.000	1.000
Lucania Dummy	795	0.026	0.160	0.000	1.000
Calabria Dummy	795	0.033	0.178	0.000	1.000
Sicily Dummy	795	0.069	0.254	0.000	1.000
Sardinia Dummy	795	0.047	0.211	0.000	1.000
North Dummy	795	0.425	0.495	0.000	1.000
South Dummy	795	0.442	0.497	0.000	1.000
Owner-operators	795	0.306	0.144	0.000	0.654
Rented tenants	795	0.070	0.081	0.000	0.477
Sharecroppers	795	0.158	0.165	0.000	0.601
Gini of Farms (size)	775	0.528	0.077	0.000	0.679
Gini of Private Ownerships (value)	752	0.565	0.039	0.383	0.677
Average Rent per Ownership	752	6.311	1.241	0.033	9.425
Collective Entities' Share of Land	736	0.174	0.145	0.001	0.693
Literacy Rate	795	0.562	0.096	0.000	0.688
Female Literacy Rate/Male Literacy Rate	795	0.632	0.064	0.000	0.738
Female-Male Ratio	795	0.720	0.073	0.000	1.124
Share of Inhabitants > 10 Years Old	795	0.619	0.036	0.000	0.784
Agricultural Families' Size	793	1.784	0.147	1.439	2.393
Share of Spread Population	795	0.228	0.164	0.000	0.663
Altitude	793	496.883	467.130	1.330	2900.000
Terrain Ruggedness	793	243.834	197.108	1.731	956.675
Malaria's Area Share	795	0.260	0.309	0.000	0.693
Distance to the Sea	795	2.989	1.768	0.000	5.381
Island Dummy	795	0.011	0.088	0.000	0.693
Latitude (km from Equator)	795	8.466	0.059	8.279	8.556
Total Rainfall	775	6.920	0.342	5.322	7.852

C.V. Total Rainfall	775	0.169	0.051	0.015	0.398
Winter Rainfall	775	5.399	0.371	4.263	6.418
Spring Rainfall	775	5.648	0.399	3.525	6.744
Summer Rainfall	775	4.923	0.795	1.288	6.608
Autumn Rainfall	775	5.715	0.344	4.437	6.623
C.V. Winter Rainfall	775	0.286	0.105	0.034	0.570
C.V. Spring Rainfall	775	0.268	0.081	0.054	0.601
C.V. Summer Rainfall	775	0.280	0.148	0.028	1.005
C.V. Autumn Rainfall	775	0.251	0.077	0.026	0.510
Winter Rain Intensity	775	2.421	0.215	1.689	3.240
Spring Rain Intensity	775	2.302	0.220	1.588	3.249
Summer Rain Intensity	775	2.368	0.316	0.424	3.263
Autumn Rain Intensity	775	2.624	0.245	1.976	3.363
Agricultural Labour Force (Families) per Hectare	793	-1.668	0.598	-3.789	1.003
Agricultural Labour Force (Members) per Hectare	793	-0.070	0.626	-2.238	2.480
Agricultural Capital per Hectare	793	7.968	0.640	5.671	9.971
Rent per Hectare	733	5.335	0.989	2.213	7.446
Access to HP generated by Water in 1911	795	6.336	0.737	0.000	8.346
Access to Markets 5 (Members) + Access Foreign Markets	793	12.116	0.239	11.416	12.854
Access to Foreign Markets	795	11.417	0.189	11.008	11.732

Note: All variables in logarithms, when necessary transformed as ln (1+x).

TABLE 1: Access to Markets and Agricultural Output - Alternative Definitions of Access to Markets

Dependent Variable: Agricultural Output per Hectare						
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
Access to Markets 1 (Total Population)	1.324***					
	(0.069)					
Access to Markets 2 (Agglomerated Population)		1.503***				
		(0.073)				
Access to Markets 3 (Agg. Pop.>10,000)			1.461***			
			(0.067)			
Access to Markets 4 (Non-Agricultural Families)				1.106***		
				(0.055)		
Access to Markets 5 (Non-Agricultural Individuals)					1.158***	1.809***
					(0.058)	(0.131)
Regional Dummies	NO	NO	NO	NO	NO	YES
Constant	-8.684	-10.391	-8.831	-3.791	-5.867	-13.158
	0.838***	0.869***	0.745***	0.564***	0.668***	1.491***
Number of obs	793	793	793	793	793	793
F-Statistic	372.33	423.57	478.19	398.32	399.62	57.40
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
R-squared	0.328	0.350	0.401	0.319	0.329	0.511
Root MSE	0.543	0.534	0.513	0.546	0.543	0.468

Notes: Robust Standard Errors in Parenthesis; * significant at 10%, ** significant at 5%, *** significant at 1%. All variables in logarithms, when necessary transformed as ln(1+x).

TABLE 2: Access to Markets and Agricultural Output – Robustness Checks					
Dependent Variable: Agricultural Output per Hectare					
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Access to Markets (Non-Agricultural Individuals)	1.158***	1.088***	1.175***	1.231***	1.154***
	(0.058)	(0.059)	(0.083)	(0.086)	(0.092)
Owner-operators		-1.456***	-1.038***	-0.897***	-0.878***
		(0.269)	(0.328)	(0.303)	(0.280)
Rented tenants		-0.759***	-0.438	-0.414	-0.152
		(0.252)	(0.301)	(0.264)	(0.278)
Sharecroppers		-0.558***	-0.244	-0.352*	-0.137
		(0.137)	(0.229)	(0.203)	(0.203)
Gini of Farms (size)		-1.362***	-1.570***	-0.956**	-0.574
		(0.344)	(0.396)	(0.373)	(0.366)
Gini of Private Ownerships (value)		-0.743	-0.422	-0.341	-0.905
		(0.689)	(0.779)	(0.606)	(0.573)
Average Rent per Ownership		0.050*	0.086***	0.082***	0.045
		(0.028)	(0.032)	(0.030)	(0.029)
Collective Entities' Share of Land		-1.211***	-0.958***	-0.733***	-0.786***
		(0.171)	(0.188)	(0.204)	(0.225)
Literacy Rate			-1.108**	0.180	0.283
			(0.478)	(0.475)	(0.481)
Female Literacy Rate/Male Literacy Rate			0.693	-0.637	0.022
			(0.540)	(0.549)	(0.571)
Female-Male Ratio			0.389	0.986***	0.631*
			(0.400)	(0.343)	(0.337)
Share of Inhabitants > 10 Years Old			1.841	1.086	0.650
			(1.688)	(1.194)	(1.058)
Agricultural Families' Size			-0.348*	-0.297	-0.303
			(0.202)	(0.180)	(0.195)
Share of Spread Population			-0.077	0.033	0.079
			(0.157)	(0.137)	(0.138)
Altitude				-0.001***	-0.001***
				(0.000)	(0.000)
Terrain Ruggedness				0.001***	0.001***
				(0.000)	(0.000)
Malaria's Area Share				-0.335***	-0.283***
				(0.078)	(0.077)
Distance to the Sea				-0.049***	-0.042***
				(0.013)	(0.014)
Island Dummy				0.575*	0.314
				(0.313)	(0.316)
Latitude (km from Equator)				-3.717***	-4.889***
				(0.841)	(1.164)
Total Rainfall					0.943
					(0.661)
C.V. Total Rainfall					0.201
					(0.452)
Winter Rainfall					-0.484**
					(0.202)
Spring Rainfall					-0.737***
					(0.265)
Summer Rainfall					0.146
					(0.144)
Autumn Rainfall					0.334
					(0.336)
C.V. Winter Rainfall					-0.156
					(0.212)
C.V. Spring Rainfall					-0.254
					(0.313)
C.V. Summer Rainfall					-0.217

					(0.156)
C.V. Autumn Rainfall					0.227
					(0.246)
Winter Rain Intensity					0.454**
					(0.201)
Spring Rain Intensity					-0.120
					(0.213)
Summer Rain Intensity					-0.267**
					(0.133)
Autumn Rain Intensity					-0.380*
					(0.220)
North Dummy			0.011	0.238***	0.137*
			(0.077)	(0.069)	(0.079)
South Dummy			-0.009	-0.115	-0.146*
			(0.084)	(0.082)	(0.082)
Constant	-5.867***	-3.454***	-5.587***	25.136***	34.920***
	(0.668)	(0.596)	(1.675)	(7.088)	(10.015)
Number of obs	793	732	732	732	732
F-Statistic	399.62	159.87	93.38	90.74	68.42
Prob > F	0	0	0	0	0
R-squared	0.329	0.621	0.632	0.720	0.752
Root MSE	0.543	0.411	0.408	0.357	0.339

Notes: Robust Standard Errors in Parenthesis; * significant at 10%, ** significant at 5%, *** significant at 1%. All variables in logarithms, when necessary transformed as ln(1+x).

TABLE 3: The Impact of Access to Markets on Factor Intensity and Land Rents								
Dependent Variable:	Agricultural Labour per Hectare (Families)		Agricultural Labour per Hectare (Family Members)		Agricultural Capital per Hectare		Rent per Hectare	
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Access to Markets (Non-Agricultural Individuals)	0.910***	1.243***	1.088***	1.247***	1.097***	1.042***	1.314***	0.938***
	(0.060)	(0.103)	(0.059)	(0.103)	(0.055)	(0.099)	(0.093)	(0.111)
Owner-operators' share		-0.959***		-0.950***		-0.803***		-0.448
		(0.309)		(0.309)		(0.309)		(0.406)
Rented tenants' share		0.000		-0.006		-0.187		-0.072
		(0.278)		(0.278)		(0.298)		(0.307)
Sharecroppers' share		-0.031		-0.036		-0.188		-0.485**
		(0.203)		(0.203)		(0.210)		(0.235)
Gini of Farms (size)		-1.055***		-1.059***		-0.079		-0.750
		(0.405)		(0.405)		(0.360)		(0.573)
Gini of Private Ownerships (value)		-2.899***		-2.890***		-1.196*		-3.754***
		(0.584)		(0.584)		(0.635)		(0.727)
Average Rent per Ownership		-0.159***		-0.158***		-0.045		0.389***
		(0.037)		(0.037)		(0.033)		(0.044)
Entities' Share of Land		-0.669***		-0.666***		-0.533**		-0.869***
		(0.201)		(0.202)		(0.217)		(0.227)
Literacy Rate		-0.317		-0.316		1.432**		1.802***
		(0.542)		(0.542)		(0.614)		(0.571)
Literacy Rate Gap		-0.136		-0.136		0.101		-0.604
		(0.609)		(0.609)		(0.650)		(0.646)
Female-Male Ratio		0.736**		0.730**		0.017		0.781*
		(0.323)		(0.324)		(0.394)		(0.472)
Share of Inhabitants > 10 Years Old		-1.552		-1.562		0.463		-1.066
		(0.985)		(0.987)		(1.050)		(1.174)
Agricultural Families' Size		-0.560***		0.636***		-0.071		-0.255
		(0.198)		(0.198)		(0.202)		(0.227)
Share of Spread Population		-0.097		-0.096		0.194		-0.416**
		(0.146)		(0.146)		(0.149)		(0.167)
Altitude		-0.001***		-0.001***		-0.001***		-0.001***
		(0.000)		(0.000)		(0.000)		(0.000)
Terrain Ruggedness		0.001***		0.001***		0.001***		0.000
		(0.000)		(0.000)		(0.000)		(0.000)
Malaria's Area Share		-0.328***		-0.328***		-0.205**		-0.277***
		(0.086)		(0.086)		(0.082)		(0.079)

Distance to the Sea		-0.039***		-0.038***		-0.045***		-0.011
		(0.013)		(0.013)		(0.014)		(0.014)
Island Dummy		0.158		0.156		0.063		-0.578**
		(0.244)		(0.244)		(0.361)		(0.260)
Latitude (km from Equator)		-2.548**		-2.539**		-0.084		-6.098***
		(1.099)		(1.099)		(1.464)		(1.324)
Rainfall Regime (14 vars.)	NO	YES	NO	YES	NO	YES	NO	YES
North-South Dummies	NO	YES	NO	YES	NO	YES	NO	YES
Constant	-12.058***	7.178	-12.486***	6.524	-4.558***	-4.510	-9.661***	44.943***
	(0.694)	(9.446)	(0.684)	(9.445)	(0.633)	(12.817)	(1.065)	(11.369)
Number of obs	793	732	793	732	793	732	733	732
F-Statistic	228.1	38.7	334.9	52.4	397.4	49.5	200.3	135.2
Prob > F	0	0	0	0	0	0	0	0
R-squared	0.249	0.687	0.324	0.717	0.316	0.679	0.195	0.863
Root MSE	0.519	0.344	0.516	0.344	0.529	0.371	0.888	0.376

Notes: Robust Standard Errors in Parenthesis; * significant at 10%, ** significant at 5%, *** significant at 1%. All variables in logarithms, when necessary transformed as ln(1+x).

TABLE 4: The Effect of Access to Markets on Agricultural Output - Mechanisms				
Dependent Variable: Agricultural Output per Hectare				
	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)
Access to Markets	1.154***	0.350***	0.455***	0.292***
	(0.092)	(0.093)	(0.077)	(0.077)
Agricultural Capital per Hectare			0.672***	0.493***
			(0.029)	(0.041)
Agricultural Labour per Hectare		0.645***		0.280***
		(0.047)		(0.051)
Agrarian Institutions (7 Variables)	YES	YES	YES	YES
Socio-Demographic Variables (6 Variables)	YES	YES	YES	YES
Physical Variables (6 Variables)	YES	YES	YES	YES
Rainfall Regime (14 Variables)	YES	YES	YES	YES
North-South Dummies	YES	YES	YES	YES
Constant	34.920***	30.710***	37.949***	35.319***
	(10.015)	(8.049)	(6.566)	(6.284)
Number of obs	732	732	732	732
F-Statistic	68.4	147.5	172.6	203.5
Prob > F	0	0	0	0
R-squared	0.752	0.858	0.886	0.896
Root MSE	0.339	0.257	0.230	0.220

Notes: Robust Standard Errors in Parenthesis; * significant at 10%, ** significant at 5%, *** significant at 1%. All variables in logarithms, when necessary transformed as ln(1+x).

TABLE 5: Instrumental Variables Estimation								
	Dependent Variable: Agricultural Output per Hectare							
	IV	IV	IV	IV	IV	IV	IV	IV
	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Access to Markets		1.146***		0.429**		0.371**		0.263*
		(0.188)		(0.182)		(0.145)		(0.151)
Access to HP by Hydraulic Motors 1911	0.339***		0.283***		0.297***		0.282***	
	(0.022)		(0.020)		(0.021)		(0.020)	
Agricultural Labour per Hectare			0.147***	0.631***			0.139***	0.284***
			(0.012)	(0.058)			(0.017)	(0.057)
Agricultural Capital per Hectare					0.109***	0.684***	0.011	0.494***
					(0.012)	(0.036)	(0.016)	(0.041)
Agrarian Institutions (7 Variables)	YES	YES	YES	YES	YES	YES	YES	YES
Socio-Demographic Variables (6 Variables)	YES	YES	YES	YES	YES	YES	YES	YES
Physical Variables (6 Variables)	YES	YES	YES	YES	YES	YES	YES	YES
Rainfall Regime (14 Variables)	YES	YES	YES	YES	YES	YES	YES	YES
North-South Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Constant	14.751***	34.936***	11.306***	30.689***	13.442***	38.137***	11.365***	35.334***
	(3.454)	(10.000)	(3.126)	(8.066)	(3.264)	(6.648)	(3.129)	(6.295)
Number of obs	732	732	732	732	732	732	732	732
F-Statistic	115.61	65.96	142.74	144.94	128.51	172.61	138.88	201.37
Prob > F	0	0	0	0	0	0	0	0
R-squared	0.857	0.752	0.884	0.858	0.873	0.886	0.884	0.896
Root MSE	0.129	0.339	0.116	0.257	0.122	0.231	0.116	0.220

Notes: Robust Standard Errors in Parenthesis; * significant at 10%, ** significant at 5%, *** significant at 1%. All variables in logarithms, when necessary transformed as ln(1+x).

TABLE 6: Further Robustness Checks – Domestic and Foreign Markets

Dependent Variable: Agricultural Output per Hectare											
	OLS	OLS	OLS	IV	IV	IV	IV	IV	IV	IV	IV
				1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Access to Markets (Domestic)	1.154***	1.170***			1.108***		0.405**		0.375***		0.264*
	(0.092)	(0.090)			(0.187)		(0.180)		(0.143)		(0.148)
Access to Foreign Markets		2.546***		-0.783***	2.517***	-0.896***	1.483**	-1.184***	-0.427	-0.957***	-0.071
		(0.848)		(0.292)	(0.854)	(0.263)	(0.629)	(0.277)	(0.594)	(0.267)	(0.555)
Total Access to Markets (F+D)			2.139***								
			(0.185)								
Capital p.h.								0.116***	0.686***	0.021	0.495***
								(0.012)	(0.037)	(0.017)	(0.042)
Labour p.h.						0.148***	0.632***			0.132***	0.284***
						(0.011)	(0.058)			(0.017)	(0.057)
Access to HP by Hydraulic Motors 1911				0.343***		0.287***		0.300***		0.285***	
				(0.022)		(0.020)		(0.021)		(0.020)	
Agrarian Institutions (7 Variables)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Socio-Demographic Variables (6 Variables)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Physical Variables (6 Variables)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Rainfall Regime (14 Variables)	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
North-South Dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	34.920***	59.123***	45.065***	7.453*	58.962***	2.922	44.834***	2.312***	34.067***	2.469	34.661***
	(10.015)	(12.671)	(9.927)	(4.386)	(12.705)	(3.958)	(10.510)	(4.141)	(8.288)	(3.972)	(7.823)
Number of obs	732	732	732	732	732	732	732	732	732	732	732
F-Statistic	68.4	68.4	66.5	113.7	64.9	141.4	141.0	128.7	169.8	138.0	197.5
Prob > F	0	0	0	0	0	0	0	0	0	0	0
R-squared	0.752	0.756	0.751	0.858	0.756	0.886	0.860	0.876	0.886	0.886	0.896
Root MSE	0.339	0.337	0.340	0.128	0.337	0.115	0.256	0.120	0.231	0.115	0.220

Notes: Robust Standard Errors in Parenthesis; * significant at 10%, ** significant at 5%, *** significant at 1%. All variables in logarithms, when necessary transformed as ln(1+x).